Chapter IV - SAMPLING AND CONTROL OF HYDRAULIC CEMENT CONCRETE

SECTION 401 GENERAL

Reference Secs. 217, 316, 400 and 500, Road and Bridge Specifications.) See Sec. 206 for Independent Assurance sampling requirements. See Secs. 207, 411.02(d), and 416 for concrete that may be accepted without compressive strength tests.

The mixing and placing of concrete are processes requiring the Producer's and Contractor's most careful attention to detail, in order to properly control the quality of the concrete used in construction. Likewise, the verification and assurance of this quality control require that the District Concrete Technicians and Inspectors assume many and varied responsibilities and duties. The following instructions will be observed as closely as conditions permit, and any deviation may be made only on authority from the Materials Division.

Sec. 401.01 Equipment

(a) Preliminary Equipment Checks

The District Materials Engineer has certain duties to perform relative to equipment before the job starts. The mixer must be inspected to determine that it is in good mechanical condition and complies with the accuracy specified.

The approved, graduated, transparent admixture dispensers shall be checked to determine proper functioning. It is not considered that a Pyrex measuring cup is an approved device for introducing admixtures into the mix. Such a device should not be approved, although it is transparent and calibrated and the method exists for adding the solution into the water line.

The aggregate and cement scales and the batch test weights must be calibrated, certified, and sealed, as outlined in Sec. 106.04. Frequent checks of scales must be made by the District Materials Engineer during the progress of the job.

(b) Portable Concrete Compression Testing Machines

The Department may place a portable concrete compression testing machine near the job site or centrally locate the machine among several jobs, for use in testing cylinders (1) for early form removal and construction of superimposed elements in concrete work and (2) for early opening of concrete work to traffic, as outlined respectively in Secs. 404.03(j) and 404.03(m) of the Road and Bridge Specifications, or in Special Provisions. This may be done in remote job areas not easily accessible to a compression testing machine.

It is recognized that, while the portable machines will be calibrated in accordance with AASHTO T67, they may not meet all requirements of AASHTO T22. However, they are deemed sufficiently accurate for on-the-job testing for purposes outlined above. The machines may on occasion fail to function properly. Whenever erratic results appear, or there is reason to suspect a malfunction, the District Materials Engineer should be contacted for advice. At least once each year, the District Materials Engineer should also be contacted regarding recalibration of the machine.

The Contractor, at his option, may furnish a portable compression testing machine. If so, the same instructions outlined above will apply, and the machine should be similar to the units furnished by the

Department. The machine must have the approval of the Department before being authorized for use. The District Engineer is authorized to approve compression machines purchased by the Contractor. He may delegate this responsibility to the District Materials Engineer. It will be the responsibility of the Contractor to keep his testing machine in good working condition at all times and have the machine calibrated at least once each year. The testing machine must be housed in order to protect it from the weather, and sufficient working space must be provided in the enclosure for personnel to conduct the tests.

The portable machines shall meet the following specifications:

(1) The machine shall be capable of accommodating for test a standard 6" x 12" (150 mm x 300 mm) or a 4" x 8" (100 mm x 200 mm) concrete test specimen.

(2) It shall have a dial with a minimum diameter of 8 in. (200 mm) and have a minimum capacity of 200,000 lbs (90 kN). It shall further be graduated to 1,000 lb. (2 kN) increments.

(3) The pump shall have a dual range operation capacity.

(4) The platens shall be of sufficient area and thickness to accommodate the specimen without deflection.

(5) The machine must be calibrated at least once every other year to within an accuracy of 1.0 percent of its normal operating range.

(6) A label should be attached to the machine showing the last date of calibration and person or firm performing the calibration. The calibration results for each preceding year shall be kept in the records of the Owner.

(c) Air Meters

Air meters for the determination of entrained air content in hydraulic cement concrete are available from the District Materials Engineer. The air meters are charged to, and become the permanent property of, the District. Necessary repairs will be made by the Materials Division at cost.

(d) Concrete Beam Testing Apparatus

Beam testing machines are distributed by the District Materials Engineer. The beam testing machines must be returned to the District Materials Engineer upon project completion.

Whenever calibration of the testing machines is desired during the construction season, they should be delivered to the District Materials Engineer for shipment to the Materials Division, which will test and return them to the District. These machines should be calibrated at least once a year.

(e) Concrete Pavement Core Drill

A concrete pavement core drill is available upon request from the District Materials Laboratory, for coring base and pavement concrete. Since the equipment and operating crew are limited in numbers, the operating schedules are most critical, especially when there are several projects requiring coring at the same time in different areas of the District. This applies also to base concrete, since the cores preferably should be obtained prior to application of bituminous concrete mix.

For these reasons, and in order to eliminate costly and time consuming equipment moves, it is necessary that the District Materials Engineer be given written notice one week in advance of any need for the drill.

The above instructions will require careful planning and attention to construction schedules.

Sec. 401.02 Materials

(a) Handling and Stockpiling of Aggregates

Responsibility for materials begins with the receipt and stockpiling of the materials. Every possible care must be taken to prevent segregation of an aggregate, and to keep it clean. Where no provision has been made to separate the stockpiles from the ground, the location must be cleared of all vegetation and rubbish, and leveled and rolled, before the stockpiles are started. Material that has been in contact with the ground will be contaminated, and must not be used. Adjacent stockpiles of unlike material must not be allowed to come in contact with each other, and must be separated by bulkheads, if necessary. See Sec. 415.01(f) for additional precautions in the inspection of aggregate.

(b) Handling and Storage of Cement

It is the District Materials Engineer's duty to see that all cement is stored in a suitable weatherproof structure that will protect the cement from dampness. Ample storage must be provided. On small quantities, storage in the open, with ample weatherproof covering, may be permitted.

When the cement and aggregates are proportioned at one point and trucked to the mixer, the cement must be protected from moisture while in transit.

See Sec. 415.01(f) for additional precautions in the inspection of cement.

SECTION 402 AGGREGATE MOISTURE

Sec. 402.01 Physical Characteristics

It is the duty of the District Materials Engineer to check the Producer's determination of the free moisture in both the coarse and fine aggregates. The proportioning of concrete by weight assumes the aggregate to be in a saturated surface-dry condition. As nearly all aggregate has been in contact with water, a certain amount of water has been absorbed into the particles. It is essential that the particles be saturated. If they are not, they will absorb mixing water from the concrete, and give a stiff, unsatisfactory mix. Most of the aggregates used in Virginia are saturated when received on the job, and will contain approximately the following amounts of absorbed moisture:

Quartz sand and gravel	0.5 - 1.5%
Limestone and dolomites	0.5 - 1.0%
Granites and trap rock	0.5 - 1.0%

Any free or unabsorbed water in the aggregate will mix with the water added to the concrete materials, and must be accounted for as a part of the total water in reference to the water-cement ratio. The approximate quantity of adherent, or free water, will be dependent upon the size and composition of the aggregate and its method of production. These quantities may vary as follows:

Very wet sand	5 - 10%
Stockpile drained sand	2 - 5%
Damp sand	1 - 2%
Stockpile drained coarse aggregate	1 - 3%

These rough approximations are given merely as a guide as to what to expect in determining the free and absorbed moisture.

To control the water-cement ratio of concrete, there must be some degree of uniformity of water content of the aggregate. Material, from cars that permit drainage and are in transit 24 hours or more, should be comparable in moisture content with 24 hour stockpiled material. The use of material freshly delivered from the washers, dripping with water, is not to be tolerated. All such wet material must be stockpiled or permitted to drain freely, whether delivered by car, truck, or barge, for 24 hours before using.

In hot, dry weather, it may be necessary to wet down the stockpile of coarse aggregate the night prior to use, and to sprinkle it during the day. This serves two purposes: (1) to maintain the aggregate in a saturated surface-dry condition, and (2) to keep the aggregate cool by evaporation.

Aggregate particle shape also affects the water content and workability of concrete, even when using the maximum amount of mixing water allowed by specifications. Aggregate particle shape varies across the State to such an extent as to create a variation of up to 7 gallons (35 liters) of mixing water per cubic yard (cubic meter) to produce the same workability. Concrete mix designs should not be approved when the Producer proposes to use poorly shaped aggregates that are known to require more mixing water than is submitted in the mix design. In such cases, the Contractor should be advised that he should change his source of aggregate, unless he can make satisfactory adjustments in the cement content or aggregate proportions. See also Secs. 403 and 405.

Sec. 402.02 Methods of Determining Water Content

Tests to determine moisture content of aggregate shall be performed by the Producer's Technician at least twice daily, or more often as required by job conditions. An undetected increase of 2 percent of moisture in the sand and one percent in the coarse aggregate will contribute approximately 4 1/2 gallons (22 ½ liters) of additional water per cubic yard (cubic meter) to the mix, and thus reduce the compressive strength approximately 12 percent.

(a) Standard Method

(1) Field Method

A field method for determining the free water for fine and coarse aggregate is as follows:

Select a representative sample of the aggregate and determine the wet weight by weighing approximately 1000 grams (2 1/2 pounds) if fine aggregate, or up to 5000 grams (12 1/2 pounds) if coarse aggregate. The scales used should be accurate to 1/10 of one percent of the sample taken. Dry this same material by heating until all the moisture, both surface and internal, is lost. It will be satisfactory to use a microwave oven in lieu of a standard oven for rapid drying of aggregate. Weigh the dry sample accurately.

The percentage of total moisture is then determined by the following formula:

$$\text{Total Moisture (\%)} = \frac{\text{Ww - Wd}}{\text{Wd}} x100$$

Where: Ww = Wet weight of sample, and

Wd = Dry weight of sample.

The free moisture is then computed by subtracting the absorption value for the particular aggregate being used from the total moisture as follows:

Free Moisture (%) = Total Moisture (%) - Absorbed Moisture (%)

The absorption value for any particular aggregate may be found on the Aggregate Data Sheet published periodically by the Materials Division or from the District Materials Engineer's Office.

The Producer's Technician should be assured at all times that the aggregate is in at least a saturated surface-dry condition when batching.

(2) Laboratory Method

An alternate method of determining free moisture, suitable for Laboratory use, is to determine the saturated surface-dry weight of the sample. This is done by drying the above noted size of sample in a thin layer. Hasten the surface drying by stirring or by air currents, if possible. (See note in Paragraph (a)(1) above for use of microwave oven). When the fine aggregate is dry enough to flow freely when molded into a cone shaped heap or flows freely when balled by the fist, weigh the sample. This condition is determined for coarse aggregate when no signs of visible surface moisture are evident. Coarse aggregate is normally brought to this condition by simply drying the surface with a towel. Determination of this condition shall be done only by experienced, qualified personnel.

The percentage of free moisture is then determined by the following formula:

$$\text{Free Moisture (\%)} = \frac{Ww - Ws}{Wd} \times 100$$

Where: Ws = Saturated surface-dry weight.

If it is desired to determine a more specific percentage of absorbed moisture for the particular aggregate in use, other than the value shown on the Aggregate Data Sheet or the approximate values shown in Sec. 402.01, the procedures outlined above in Paragraphs (a)(1) and (a)(2) should be followed and the following formula used:

$$\text{Absorbed Moisture (\%)} = \frac{Ww - Wd}{Wd} \times 100$$

(b) Gas Pressure Method

Other instruments for use in measuring moisture content of aggregates use the principal of gas generation to create pressure, such as the "Speedy" Moisture Tester. The moisture content is read directly from the dial on the instrument and should be used strictly in accordance with the manufacturer's directions labeled on the instrument case. In using this instrument, the moisture reading obtained is the free moisture, and is that reading obtained immediately after the instrument has been activated.

SECTION 403 WATER-CEMENT RATIO

It is desirable, in order to obtain the strongest possible concrete with the specified amount of cement, to use as little water in the mix as possible and, at the same time, preserve its workability. With any given aggregate-cement mixture, the strength of the concrete is proportionate to the amount of water present in the mix. The ratio of water to cement then becomes all important. The usual form of expression is the number of pounds (kilograms) of water per pound (kilogram) of cement used, and is the basis for proportioning concrete in Virginia.

Frequently, excessive mixing water, due to hot weather concrete, causes low strength and a reduction in durability. For each gallon (5 liters) of unnecessary water per cubic yard (cubic meter) of concrete, a 2 1/2 to 3 percent reduction in strength can generally be expected. For additional details of moisture and hot weather concrete, see Secs. 402 and 407.02.

SECTION 404 FINENESS MODULUS

Fineness modulus, another factor affecting the uniformity of strength of concrete, is the index to the fineness or coarseness of an aggregate. With any aggregate, the total surface area of the particles increases as the fineness in grading increases. The higher the fineness modulus value, the coarser the aggregate. If the total surface area is controlled by the grading, then a method of expressing the degree of fineness is also a method of expressing surface area. This measure is called the fineness modulus and is expressed as the cumulative sum of all of the amounts of material retained on each sieve of the fineness modulus series of openings divided by 100.

The standard size sieves are 6 inch (150 mm), 3 inch (75 mm), 1 1/2 inch (37.5 mm), 3/4 inch (19.0 mm), 3/8 inch (9.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (600 µm), No. 50 (300 µm), and No. 100 (150 µm),. In this series, the size of each opening, beginning with the 100-mesh sieve, is one-half that of the next larger size used. The percent of material passing the 100-mesh sieve is not used in calculating the fineness modulus. For example, the fineness modulus of a fine aggregate, such as would be used in concrete, may be as follows:

FINE AGGREGATE - SAND, GRADING A

Sieve Size	Percent Retained	Cumulative Percent Retained
3/8" (9.5 mm)	0.0	0.0
No .4 (4.75 mm)	0.0	0.0
No. 8 (2.36 mm)	12.0	12.0
No. 16 (1.18 mm)	15.0	27.0
No. 30 (600 µm)	32.0	59.0
No. 50 (300 µm)	18.0	77.0
No. 100 (150 µm)	13.0	90.0
No. 200 (75 µm)	10.0	100.0 (Not Include.)
		Total = 265.0

$$\frac{2.65}{100} = 2.65 = \text{F.M.(Ans.)}$$

NOTE: Although the No. 200 (75 µm), sieve is normally used to determine grading, this sieve does not belong in the fineness modulus series of sieves. Consequently, the cumulative percent of material retained on this sieve is not included in the sum total when computing the fineness modulus.

The fineness modulus is used for the purpose of estimating the proportion of fine and coarse aggregate to be used in the concrete mix design. It should not vary more than 0.2 for any one job if uniformity of strength is to be expected, as uniform consistency and constant water-cement ratio cannot be maintained otherwise. If it varies more than 0.2, then the mix should be redesigned.

SECTION 405 PROPORTIONING OF AIR-ENTRAINED CONCRETE

Sec. 405.01General

Although there are several methods for proportioning air-entrained concrete, the one recognized by the Department is the "Recommended Practice for Selecting Proportions for Concrete (ACI 211)", with modifications conforming to the Road and Bridge Specifications or to those outlined herein. The District Materials Engineer shall approve or disapprove the mix design submitted by the Contractor, as outlined in Sec. 106.01, after checking the design carefully to see that it conforms in detail with the above specified method. It must be remembered that, whatever method is followed, the first batch of concrete should be considered only as a trial batch.

The concrete Producer shall assume the responsibility for the quality control and condition of all materials during the handling, blending, and mixing operations. The Producer shall assume responsibility for the initial determination and all necessary subsequent adjustments in proportioning of materials used to produce the specified concrete. The proportion of fine and coarse aggregate shall satisfy proper finishing requirements, and actual batch quantities may be adjusted during the course of the work to reduce changes in workability caused by difference in characteristics of aggregates within specification requirements. Such adjustments are to be made only by the concrete Producer and in such a way as not to change the yield.

Sec. 405.02 ACI Concrete Mix Design Utilizing Conventional Materials

The mix design submitted for approval by the Contractor will be that based on saturated surface-dry conditions of the aggregates. For purposes of establishing concrete proportions and calculating yields, we will not concern ourselves with bulk yield or bulk volumes of aggregates, cement, etc., but with the Absolute Volume of these materials. This means the volume of material is solid and without voids.

The Fineness Modulus and Specific Gravity for aggregates are to be taken from the current Aggregate Quality Lists published by the Materials Division. See list in Sec. 209. Other information required for use in the design of a concrete mixture will be found in the Road and Bridge Specifications, the ACI 211, or by test.

(l) Class of concrete to be designed.
(2) For fine aggregate:
- (a) The specific gravity.
- (b) The fineness modulus.

(3) For coarse aggregate:
- (a) Maximum size aggregate.
- (b) Specific gravity.
- (c) Unit weight (dry-rodded unit weight).

(4) From VDOT Specifications: (Table II-17).
- (a) Cement factor (minimum cement content).
- (b) Water-cement ratio (maximum W/C ratio).
- (c) Air content (mean air content).
- (d) Maximum size aggregate.

(5) Other information:
- (a) ACI Table A1.5.3.6 (volume of coarse aggregate per unit of volume of concrete).
- (b) TL-27 (concrete mix design form).
- (c) ACI Mix design work sheet may be used.
- (d) Source of all materials going into the mix.

There are five (5) materials going into this mix:

(1) Cement,

(2) Water,

(3) Air,

(4) Coarse Aggregate, and

(5) Fine Aggregate.

Solve for the Absolute Volume of each of the 5 materials in the mix. The combined volume must total one cubic yard (27.00 cu. ft.)(1.0 m^3).

Quantities for 3 of the 5 materials are given by the specification. These are:

(1) Cement,

(2) Water, and

(3) Air.

This means then that the designer only has to solve for the quantities of 2 ingredients:

(1) Coarse Aggregate, and

(2) Fine Aggregate.

For a more thorough examination of the mix design process, complete with example problems, please refer to the Hydraulic Cement Concrete Plant Certification Study Guide.

The requirement for a 5 percent reduction in water content of concrete, in which set retarder admixtures are used, applies to laboratory test approval only. For job use, the maximum allowable water specified in Table II-17, Road and Bridge Specifications, may be utilized by the Contractor, provided that the slump, etc., is not exceeded and provided that the value is used in the approved mix design, submitted on Form TL-27. See also Sec. 415.02(f).

Sec. 405.03 ACI Concrete Mix Design Utilizing Fly Ash

When fly ash is utilized as an additive in concrete, it must conform to the requirements of ASTM C618, Class C or F, except that the Loss on Ignition shall be limited to a maximum of 6%. The weight of the cement, when Class F fly ash is used, may be reduced a maximum of 15%. The minimum total cementitious materials are specified in Table II-17.

The weight of the fly ash to be added shall be a minimum of the amount of the weight of the cement removed. Additional fly ash up to 1.2 times the weight of the cement removed may be used to improve workability or strength.

The method of design is very similar to that used in the previous mix design in this chapter.

(Note: The specific gravity of fly ash will vary; therefore, the most current gravity from the District Materials Division should be used).

Sec. 405.04 ACI Concrete Mix Design Utilizing Granulated Iron Blast-Furnace Slag

When granulated iron blast-furnace slag is utilized as an additive in concrete, it must conform to the requirements of ASTM C989, Grade 100 or 120.

Granulated iron blast-furnace slag shall not exceed 50 percent of the total cement-granulated iron blast-furnace slag weight.

The method of design is very similar to designs previously covered in this section.

(Note: The specific gravity of slag will vary; therefore, the most current gravity should be obtained from the District Materials Division).

Sec. 405.05 Allowable Field Adjustments

After determining the weight for each of the components of the mix, the District Materials Engineer, at his discretion, may desire to make a trial batch with the aggregates, cement, and air-entraining agent to be used on the job.

If the quantities calculated by ACI absolute volume method do not give the required workability and consistency in the field, the mix can be adjusted by an allowable interchange of coarse aggregate and fine aggregate. The interchange of coarse aggregate and fine aggregate may vary the weight of coarse aggregate and fine aggregate 5 percent, but neither may be changed more than 5 percent. When an interchange of aggregate is needed, the fine aggregate, normally being of less weight than coarse aggregate, is increased or decreased 5 percent and then the coarse aggregate is changed by an equal volume so the design will be 27 cubic feet (1 m^3).

The 5 percent adjustment can be used to improve the workability by increasing the amount of fine aggregate, thereby making the concrete have a higher mortar content, or it can be used to increase the slump of the concrete by reducing the surface area of the aggregate by reducing the fine aggregate with its large surface area and replacing it with coarse aggregate.

Since the specific gravity of aggregate varies widely with type, it must be known for the aggregate being used. Small differences in specific gravity can mean large differences in batch weights.

Sec. 405.06 Batch Weight Adjustments

It is the duty of the Producer to compute the moisture content and batch weight adjustments. Moisture contents are determined as follows:

Since the free moisture on the aggregate will eventually become a part of the mixing water, it is now necessary to deduct the water which is free moisture from the mix design.

Since most aggregates will contain free moisture (Section 402.02) in the field under batching conditions, it will be necessary to correct the saturated surface-dry design mass to obtain the adjusted batch quantity. The quantity of free moisture is determined by multiplying the aggregate design mass by the free moisture content expressed as a decimal. The quantity of free moisture is then added to the saturated surface dry mass of the aggregate to determine the quantity of the aggregate to be batched. The free moisture that has been added with the fine and coarse aggregate is to be considered part of the mixing water, and as such must be totalled and the total subtracted from the quantity of the water shown in the mix design. Excessive water content in the mix decreases the strength and durability of the concrete.

NOTE: Moisture contents of aggregate are based on dry weights. However, once the weight of free water is determined, it must be added to the saturated surface-dry weight to obtain the wet batch weight.

Sec. 405.07 Remediation of Alkali Silica Reaction

Alkali Silica Reaction is a reaction between the alkalies in concrete and reactive aggregates causing expansion and usually showing up as cracks in concrete. Cement is the principal source of the alkalies in concrete. There are several ways of controlling ASR: use low alkali cement, use non-reactive aggregates, keep moisture away, and mitigate the reaction with mineral admixtures. The first three options are not plausible in Virginia, so mitigation of the reaction is the most practical approach for control.

The method of measurement of potential expansion of the cementitious materials is by ASTM C-441, which uses crushed pyrex glass as the reactive aggregate. The 56 day results are used, since the results of the test are inconclusive at 14 and 28 days. It has been determined that we should limit the expansion of the samples to a maximum of 0.10%.

Certain combinations of cement/mineral admixture have been found to be effective based on the alkali content of the cement. These minimum quantities are tabulated below. Approval of lower total mineral admixture contents or a new mineral admixtures may be obtained by test results furnished to the Department for assessment. The assessment should be based on testing performed at a minimum of three alkali levels, each level will include a control cement, and a cement with the proportion of mineral admixture requested. These test values should be normalized in accordance with equation 5 in VTRC 95-R21 - Use of Fly Ash, Slag, or Silica Fume to Inhibit Alkali-Silica Reactivity by D. Stephen Lane and H. Celik Ozyildirim.

Combination of Cementitious Materials	Maximum Cement Alkali
Cement Only	0.45%
Cement with Minimum 15% Class F Fly Ash	0.60%
Cement with Minimum 20% Class F Fly Ash	0.68%
Cement with Minimum 25% Class F Fly Ash	0.75%
Cement with Minimum 30% Class F Fly Ash	0.83%
Cement with Minimum 25% Slag	0.60%
Cement with Minimum 35% Slag	0.90%
Cement with Minimum 50% Slag	1.00%
Cement with Minimum 3% Silica Fume	0.60%
Cement with Minimum 7% Silica Fume	0.90%
Cement with Minimum 10% Silica Fume	1.00%

The maximum amount of mineral admixture is controlled by specifications. The minimum amount of mineral admixture is controlled by the alkali content of the cement. The proportions used may be any amount within the limits of minimum to maximum.

A precautionary note: the strength of the concrete at early ages is retarded by the use of mineral admixtures. Mineral admixtures replace cement and rely on the byproducts of hydration for reaction. To improve the strength gain in colder weather, additional amounts of cementitious materials may be added, or the concrete mixing and curing temperatures may be increased.

SECTION 406 USE OF ADMIXTURES

Admixtures are minerals or chemicals that are added to the concrete during batching operations in order to obtain certain desirable characteristics in the plastic and/or hardened concrete. Mineral admixtures include fly ash and granulated blast-furnace slag. Chemical admixtures include air-entraining agents, set retarders, accelerators, water-reducing and high range water-reducing agents.

The chemical admixtures most frequently used are air-entraining agents and set retarding admixtures. Accelerators and water-reducers are used in special situations. These admixtures impart such beneficial characteristics as high compressive strength, resistance to weathering, low water-cement ratios, increased workability, durability, and delay or increase in initial set among other things.

Use of admixtures must be strictly controlled at all times. The use of admixtures and the procedure for using them must be determined for actual job conditions for each job. No standard pattern can be prescribed to fit all jobs, since all jobs and materials differ. Proper discretion on the part of the Inspector must prevail.

Following are some of the most important features of, and precautions to be exercised with, the use of admixtures. Caution should be taken to assure that the correct admixture is being added at the concrete plant. Inspectors should check to ensure that not only the brand name is correct, but also all of the Manufacturer's identifying product numbers or letters are correct.

It is also imperative that the Inspector not allow different admixtures to come in contact with each other, nor allow any admixture to come in contact with raw cement, prior to the admixtures being dispensed separately into the water line. Admixtures will be combined with the mixing water prior to batching, in order that the admixtures will be more thoroughly mixed with all the materials in a uniform way in each batch of concrete. If the admixture is not distributed uniformly throughout the batch, or if too much admixture is placed in the batch, soft or "green" spots (with set retarders) will occur in the final cast unit, that will not attain final set to allow proper finishing or stress release, in the case of prestressed concrete. If this situation occurs with air-entraining admixtures, air content will vary considerably, probably outside of specification tolerances, from one part of the batch to another.

Set retarders are used to delay the initial set of concrete during hot weather, to allow time for proper finishing, and, in the case of prestressed concrete, to provide a uniform time from which to measure the delay period before accelerated curing. When used for these purposes, and when in accordance with Manufacturer's recommendations, the usual procedure is to decrease the amount of admixture as the placement progresses, in order that each individual portion or segment of the casting will gain initial set at the same time. At the same time, however, the amount of admixture probably will have to be increased as the atmospheric temperature increases. The proper procedure will be determined by the type and brand of admixture being used. Some types available are best used in the same amount throughout the entire placement and, in some cases, even when the temperature may be quite variable.

Caution should be exercised, however, not to use set retarders indiscriminately in cold weather, even though specifications may require its use, unless specifically waived in writing by the Engineer. As a rule, a retarding admixture should not be used when the temperature is below 60^{o}F., unless it is necessary to derive certain special benefits required by job conditions. Project personnel should contact the District Materials Engineer when the weather conditions are such that they are having difficulty in deciding upon the use of the retarder. There can be cases of frozen concrete and low strength, due to cold weather compounded by the use of retarding admixtures, although the Contractor is responsible for protection regardless of when final set occurs.

The Contractor should be encouraged to submit several alternate mix designs for placements to be made during different seasons of the year. The particular mix could then be selected that would be compatible with the weather conditions being encountered.

Caution should be exercised with the use of mineral admixtures in cold weather, or if time is critical to the schedule, because the strength gain is slower at early ages than mixes without the admixtures.

Sec. 406.01 Addition of Admixtures

Admixtures should be added during batching to assure maximum uniformity in the mixture of concrete. If the air content of the concrete has been determined to be low by the use of the pressure meter, additional air entraining admixture may be added one time, to the concrete in those loads that are on site or in transit. The proper addition rate is to be determined by and the addition made under the supervision of the producers certified technician. The quantity should be measured in a clear, graduated, measuring device, and added to a minimum of one to two gallons (4 to 8 liters) of water prior to addition to the mixture, provided the water-cement ratio is not exceeded. The mixer drum should be reversed to allow the additional air entraining admixture to be dispensed directly on top of the concrete mixture. An additional 70 revolutions of the mixer should be made at full mixing speed to thoroughly disperse the admixture throughout the concrete. The concrete is then to be retested for conformance to the specifications. If the increased dosage does not provide air contents within the specified range, the concrete shall be rejected.

In the concrete to be batched, after the initial field adjustment, the air content must be adjusted at the plant and verified before shipment.

On finding the air content low, the Contractor or his representative will be responsible for performing the quality control testing of the load of concrete to assure compliance with specifications, and continue testing subsequent loads until the concrete is determined to be in conformance with specifications. Quality control tests will be performed prior to addition of the air entraining admixture, after addition of the air entraining admixture, and after any subsequent additions of water, high range water reducer, etc. Acceptance tests will still be required to be performed by the Department, but should be run following the beginning of full discharge, rather than prior to any concrete being discharged into the forms.

SECTION 407 PLACEMENT AND CURING OF CONCRETE

No matter what care has been taken in the preparation of the materials, the uniformity of the mix, or the design of the concrete, many of the advantages gained by this care are lost if the concrete, during or after placing, is not maintained at the proper temperature or is not properly cured. These latter processes are equally as important as all the others combined. The retention of moisture in the concrete and the maintenance of proper temperature during the curing period are the most effective means of ensuring the maximum ultimate strength desired. See Sec. 413.05 for the proper procedure in curing prestressed concrete.

Sec. 407.01 Adequate Moisture

The treatment received by the concrete during the first 24 hours after it is placed is by far the most important, and the strength lost by failure to keep the concrete moist during this period never can be regained. Using uncured concrete as a basis for comparison, proper curing during the first 72 hours will increase the modulus of rupture about 20 percent and resistance to wear about 35 percent. Seven (7) days curing raises these figures to 30 percent increase in modulus of rupture and 40 percent increase in wear resistance. It is, therefore evident that the water mixed in the concrete should be retained, especially on the surface, from the minute the concrete is finished until adequate curing is obtained. Continuous curing during the entire specified period is absolutely essential. Should water be necessary for curing, and there is not enough for both curing and mixing the concrete, then the mixing and placing of concrete must be suspended until sufficient water is available.

Sec. 407.02 Proper Temperature

In cold weather placement of concrete, every effort should be made to place and cure the concrete at the optimum curing temperature of 55°F (13°C). All precautions should be taken to protect and cure the concrete at this temperature. In hot weather, this is not feasible, but all efforts should be made to mix and place the concrete at as low a temperature as possible.

It is important in hot weather to mix and place the concrete at or below the air temperature. Whenever the air temperature is appreciable below the concrete temperature, rapid drying conditions are produced that may result in plastic shrinkage cracking. Plastic shrinkage cracking is random cracking that sometimes occurs at the surface of fresh concrete soon after it has been placed and while it is still plastic. The temperature differential that will produce rapid drying will vary the other environmental conditions, but in hot weather, a differential of 10°F (5°C) may be sufficient.

If there is an appreciable delay between finishing and initiation of proper curing, without adequate water fogging , and/or other protective measures, plastic shrinkage cracking may even occur when the concrete temperature is at or below the air temperature, depending on humidity. If the temperature of the surface on which thin concrete overlays are to be placed is above the concrete temperature, the concrete temperature will be increased and may aggravate cracking probability.

Plastic shrinkage cracking is usually associated with hot weather concreting; however, it can occur at any time when circumstances produce rapid evaporation of moisture from the concrete surface. In Virginia, plastic shrinkage cracking is most likely to occur in the Spring and Fall when wind velocities are up, humidity is down and temperatures are moderate. Such cracks may appear when evaporation exceeds the rate at which bleed water rises to the surface of concrete. It should be noted that in the case of thin concrete overlays, there is less water to bleed to the surface due to high surface area to depth ratios and lower limits on the water cement ratio, therefore, overlays are more susceptible to plastic shrinkage cracking than are regular deck placements. The following conditions, alone or combined, increases evaporation of surface moisture and increase the probability of plastic shrinkage cracking:

(1) Concrete temperatures higher than air temperature,

(2) Low humidity, and

(3) High winds.

For example, when the concrete temperature is 70°F (20°C) and the air temperature is 40°F (4°C), the temperature of a layer of air immediately above the slab will be raised; hence, its relative humidity will be reduced and shrinkage cracking will frequently occur.

The chart shown in Appendix IV-C-1 is useful for determining when precautionary measures should be taken. There is no way to predict with certainty when plastic shrinkage cracking will occur.

The contractor shall have the equipment to determine the evaporation rate for all deck concrete placements. This will require a method of determining wind velocity, relative humidity, concrete temperature and air temperature.

Before commencing deck concrete placement, the contractor will determine the wind velocity, relative humidity, concrete temperature and air temperature. He will use Appendix IV-C-1 to determine the expected rate of evaporation from the concrete surface. If this value is above 0.1 lb./ft^2/hr (0.5 kg/m^2/hr) for A4 concrete, the contractor must take extra precautions to prevent plastic shrinkage cracking, and if this value is above 0.2 lb./ft^2/hr (1.0 kg/m^2/hr) for A4 concrete, the contractor should advise that plastic shrinkage cracking conditions are severe. If this value is above

0.05 lb./ ft^2/hr (0.25 kg/ m^2/hr) for latex modified concrete overlays and other hydraulic cement overlays with a w/c < = 0.40 the contractor must take extra precautions to prevent plastic shrinkage cracking, and if this value is above 0.15 lb./ ft^2/hr (0.75 kg/m^2/hr) the contractor is advised that plastic shrinkage cracking conditions are severe and placement should not begin unless precautions are taken. A change in environmental conditions during placement operations may aggravate plastic shrinkage and thus conditions should be monitored periodically throughout the operation, especially if there is a noticeable increase in wind velocity or a drop in air temperature. If these measurements indicated an increased risk in plastic shrinkage cracking, additional precautions should be taken to prevent cracking. If conditions are severe enough, placement should be suspended at the earliest practical point.
The simple precautions listed below can minimize the possibility of plastic shrinkage cracking. They should be considered when planning an concrete construction job, or when dealing with the problem if it occurs after construction is started. They are not listed in order of importance, but more nearly in the order in which they might occur in construction:

(1) Dampen the subgrade and forms.

(2) Dampen the aggregates if they are dry and absorptive.

(3) Erect windbreaks to reduce wind velocity over the concrete surface.

(4) Erect sunshades to reduce concrete surface temperatures.

(5) Lower the fresh concrete temperature.

(6) Avoid overheating the fresh concrete during cold weather.

(7) Protect the concrete with temporary wet coverings and/or a monomolecular film during any appreciable delay between placing and finishing.

(8) Reduce time between placing and start of curing by improved construction procedures.

(9) Apply curing compound promptly, as soon as the water sheen has disappeared.

(10) Protect the concrete during the first few hours after placing and finishing to minimize evaporation. This is most important to avoid checking and cracking. Application of moisture to the surface, using a fog spray nozzle, is an effective means of preventing evaporation from the concrete. This should be used until a suitable curing material, such as a curing compound, wet burlap, or curing paper can be applied. However, spraying to assist in finishing is not acceptable, as this may do more harm than good by diluting and weakening the cement paste at the surface.

The mixing of concrete at high temperatures can be detrimental to the concrete, as the following things can happen:

(1) The ultimate strength is lowered.

(2) The water requirement for mixing is increased, resulting in greater shrinkage upon drying.

(3) The concrete will be less resistant to freezing and thawing.

(4) The concrete tends to crack more freely.

Although it may not be feasible to obtain concrete temperatures below 70°F (25°C) during the summer months without the use of ice or other drastic cooling measures, it is practical to adopt practices that will appreciable reduce the temperature of fresh concrete. Hot weather concreting practices and the prevention of shrinkage cracking are covered in more detail in publications, such as those prepared by the Portland Cement Association and the American Concrete Institute. It is expected that the concrete industry adopt as a minimum standard the rudimentary hot weather concrete practices known and utilized for more than 30 years. (See also Sections 402.01 and 403.)

Efforts to lower the maximum temperature of the concrete may include, but not be limited to:

(1) Sprinkling of stockpiles,

(2) Obtaining mixing water from the coolest source available,

(3) Burying, insulating, shading, or painting white all tanks and pipelines holding or carrying mixing water, and

(4) Painting of mixing drums on transit mix trucks white, to reflect heat from the sun.

If it is found necessary to use ice as a portion of the mixing water to obtain the proper concrete temperature, the ice shall be considered the same as mixing water. It shall be batched to the same degree of accuracy and in such proportions as will secure the desire concrete temperature.

See Section 406 for details in the use of admixtures.

SECTION 408 CONSISTENCY OF CONCRETE

The consistency of concrete is the most practical measure that can be used to determine its workability. While these 2 characteristics are not identical, they are sufficiently close in their relationship to use the consistency, as measured by the slump test, as a measure of workability. Consistency tests shall be made by the slump method, in accordance with AASHTO T119.

For structural concrete (bridges, box culverts, and retaining walls), at least one test shall be made from each batch of concrete, prior to the concrete being placed in the forms. For prestressed concrete, consistency tests shall be made by the Producer's Certified Concrete Technician on the same batches of concrete from which compressive strength cylinders are made. For miscellaneous concrete (all concrete except pavement and that noted above), at least one test per day shall be made, prior to the concrete being placed in the forms. Caution should be exercised against setting routine times for taking slump tests of miscellaneous concrete, to avoid predictions as to which load is to be tested.

Should the test on a batch reveal the concrete to be out of specification range, the following steps shall be taken: (See Sec. 413 herein for proper control of prestressed concrete.)

(1) The Inspector will immediately perform a recheck test on the same batch. Should the results confirm the original test, the load shall be rejected.

(2) The Inspector will immediately inform the Contractor's representative of the test results.

(3) The Contractor's representative shall be responsible for notifying the Producer, through a pre-established means of communication, the results of the test.

For pavement concrete, at least 2 slump tests shall be made daily.

For all concrete, slump tests shall be made whenever the consistency of the concrete appears to change, or whenever otherwise desirable. In addition, consistency tests shall be made on the same batch of concrete that is sampled for compressive or flexural strength specimens. Results of all consistency tests will be recorded as a permanent record of the project.

The sample of concrete for structural, prestressed, or miscellaneous shall be taken, as outlined in Sec. 411.02(b), except that the sample shall be taken after not less than 2 cubic feet (0.05 m^3) of concrete has been discharged from the batch being sampled, and prior to placing the concrete in the forms. For pavement concrete, the sample shall be taken, as outlined in Sec. 412.02(a).

The results of consistency tests shall be recorded on Forms TL-13 or TL-13A, TL-26 (TL-26A, if computerized cylinder input form), and TL-28A (computerized batch input form), as outlined in Sec. 800.

SECTION 409 DETERMINATION OF AIR CONTENT

When air-entrained concrete, or concrete containing admixtures that entrain air, is being produced, it is necessary to control the amount of entrained air in the mix.

Air content tests shall be made by the pressure method, in accordance with AASHTO T152, by the displacement method, in accordance with AASHTO T199, or by the volumetric method, in accordance with AASHTO T196.

The Chace Indicator, displacement method, measures only the air content of the mortar. The fraction of coarse aggregate affects the quantity of mortar per cubic yard (cubic meter) of concrete; therefore, mortar correction factors must be used. Also, because of differences in the manufacture of the indicators, a Chace factor must be included. These corrections are included in the Chace Nomograph at the end of this section.

Chace Air Indicator recorded air contents shall be the average of two (2) readings. If the 2 air content readings vary more than 2% from each other, then a third reading must be taken and the average of the three (3) recorded as the air content. Air content results determined by the Chace Indicator to be within Specifications may be used for acceptance of the concrete; however, rejection because of air content must be as a result of failures determined by means of the pressure meter, as required in Sec. 217.08 of the Road and Bridge Specifications.

Only the pressure or volumetric methods are to be used to determine air content in freshly mixed concrete placed in <u>bridge decks</u>. The frequency of tests is to be one (1) per truckload for the first 3 trucks arriving at the job site and every third truck thereafter, provided results are maintained within 1% of the median of the design range. This frequency is to be initiated at the start of each day's operation or whenever a change is made in the mix design.

For <u>structural concrete</u> (bridges, except decks, box culverts and retaining walls), at least one test per load of concrete shall be made prior to the concrete being placed in the forms. For <u>prestressed concrete</u>, tests shall be made by the Producer's Certified Concrete Technician on the same batches of concrete from which compressive strength cylinders are made, using the Pressure Method only. For <u>miscellaneous concrete</u> (all concrete except pavement and that noted above), at least one test per day shall be made prior to the concrete being placed in the forms. Caution should be exercised against setting routine times for taking air tests of miscellaneous concrete, to avoid predictions as to which load is to be tested.

Should the test on a batch, conducted by either method, reveal the concrete to be out of specification range, the following steps shall be taken: (See Sec. 413 herein for proper control of prestressed concrete.)

(l) The Inspector will immediately perform a recheck test on the same batch using the pressure type meter. Should the results confirm the original test, the load shall be rejected.

(2) The Inspector will immediately inform the Contractor's representative of the test results.

(3) The Contractor's representative shall be responsible for notifying the Producer, through a pre-established means of communication, the results of the test.

For pavement concrete, at least one test shall be made each hour during pouring operations.

For all concrete, air tests shall also be made on the same batch of concrete which is sampled for compressive or flexural strength specimens. Results of all air tests will be recorded as a permanent record of the project.

Air meters, supplied by the District Materials Engineer, are available for field use. For each air meter, the appropriate instructions, delivered with, and especially applying to, the air meter should be used.

The sample of concrete for structural, prestressed, or miscellaneous shall be taken, as outlined in Sec. 411.02(b), except that the sample shall be taken after not less than 2 cubic feet (0.05 m^3)of concrete has been discharged from the batch being sampled and prior to placing the concrete in the forms. For pavement concrete, the sample shall be taken, as outlined in Sec. 412.02(a).

One of the most frequent causes found for strength failures is an excessive amount of entrained air. A proper amount of entrained air is necessary for durability; however, compressive strength is reduced approximately 5 percent for each one percent increase in air content, for equal water-cement ratios.

It should also be noted that both the Chace Indicator and pressure meter tend to read low when the air content begins to approach 9 percent; thus, the actual air content may be even higher than what is actually being measured and recorded. A correction factor shall be applied, particularly when the Chace Indicator is being used on concrete in which the mortar content varies from l5 cubic feet (0.55 m^3) per cubic yard (cubic meter).

Whenever the air contents of several loads of concrete begin to reveal a trend away from the target value (middle of specification range), the test data should be brought to the attention of the Contractor immediately, together with a request that he have his concrete Producer adjust the dosage of entraining agent until the resultant air content moves back to the center of the allowable range.

For example, when 6 1/2 ± 1 1/2 percent entrained air is specified, we are saying to the Contractor that we want 6 1/2 percent, but recognizing inherent variables that exist in materials and environmental conditions, we will accept occasional loads in which the air content is as low as 5 percent and as high as 8 percent. It is not the intent of the specifications to accept the bulk of such concrete at the 5 or 8 percent limit. This intent is detailed in Sec. 200.01 of the Road and Bridge Specifications.

The results of air content tests shall be recorded on Forms TL-13, or TL-13A, TL-26 (TL-26A, if computerized cylinder input form), and TL-28A (computerized batch input form), as outlined in Sec. 800.

As noted above, when using the Chace Indicator, a Chace factor must be included. Each indicator will have its Chace factor shown on the bulb of the indicator. This is used as shown in the table and example below.

CHACE CONVERSION TABLES

To determine the mortar corrected air content, multiply stem reading by the appropriate mortar correction factor based on the Chace Factor and the mortar content of the concrete.

Mortar Correction Factors

Mortar Content (c.f.)	Chace Factor 1.6	1.8	2.0	2.2	2.4
27	1.60	1.80	2.00	2.20	2.40
20	1.19	1.33	1.48	1.63	1.78
19	1.13	1.27	1.41	1.55	1.69
18	1.07	1.20	1.33	1.47	1.60
17	1.01	1.13	1.26	1.39	1.51
16	0.95	1.07	1.19	1.30	1.42
15	0.89	1.00	1.11	1.22	1.33
14	0.83	0.93	1.04	1.14	1.24
13	0.77	0.87	0.96	1.06	1.16
12	0.71	0.80	0.89	0.98	1.07
11	0.65	0.73	0.81	0.90	0.98
10	0.59	0.67	0.74	0.81	0.89

Based on the mortar corrected air content, select and record the actual air content as shown below.

Curve Corrected Air Contents

Mortar Corrected Air, %	Actual Air, %	Mortar Corrected Air, %	Actual Air, %
2.0	2.0	5.5	6.1
3.0	3.2	6.0	6.7
3.5	3.8	6.5	7.3
4.0	4.3	7.0	7.8
4.5	4.9	7.5	8.4
5.0	5.5	8.0	9.0

EXAMPLE: The Chace Indicator reading is 4.0% on a mix with a mortar content of 60%. The indicator has a Chace Factor of 2.0. From the Table, the mortar correction factor would be 1.19. Multiply the Chace reading of 4.0 by the mortar correction factor of 1.19 for a mortar corrected air content of 4.76%. Interpolating between 4.5% and 5.0% mortar corrected air contents, the curve corrected actual air would be 5.2%.

SECTION 410 YIELD OF MIX

Sec. 410.01 Definition of Yield

Yield is defined as the volume of concrete produced, in cubic yards (cubic meters), as determined by dividing the total weight of all materials included in the batch, by the weight of the concrete as determined by unit weight test.

Sec. 410.02 Method

Yield shall be determined by the method outlined in AASHTO T121, or as modified herein.

Sec. 410.03 Sample

The sample of freshly mixed concrete shall be obtained, as outlined in Sec. 411.02(b). Yield shall be determined whenever desirable, or as directed by the District Materials Engineer, when deemed necessary for proper control of the batching operations.

Sec. 410.04 Calculations

(a) Unit Weight

The net weight of the concrete shall be calculated by subtracting the weight of the measure used in the test from the gross weight. The unit weight shall be calculated by multiplying the net weight by the factor for the measure used. The method of determining this factor is given in AASHTO T121.

(b) Yield of Concrete

The yield of concrete produced per batch shall be calculated as follows:

English: $Y = \dfrac{(\mathrm{N \times 94}) + \mathrm{Wf} + \mathrm{Wc} + \mathrm{Ww}}{\mathrm{W}}$ Metric: $Y = \dfrac{\mathrm{Whc} + \mathrm{Wfa} + \mathrm{Wca} + \mathrm{Ww}}{\mathrm{W}}$

Where: Y = Yield of concrete produced per batch, in cu. ft. (m^3),

N = Number of bags of cement in the batch,

94 = Net weight of a bag of cement, in lbs.,

Whc = Total weight of cement in the batch (kg)

Wfa = Total weight of fine aggregate in batch in condition used, in lbs. (kg),

Wca = Total weight of coarse aggregate in batch in condition used, in lbs. (kg),

Ww = Total weight of mixing water added to batch, in lbs. (kg), and

W = Weight of concrete, in lbs. per cu. ft. (kg/ m^3)

(c) Relative Yield

Relative yield is the ratio of actual volume of concrete obtained to the volume as designed for the batch and shall be calculated as follows:

$$Ry = \frac{Y}{Yd}$$

Where: Ry = Relative Yield of concrete

Y = Yield of concrete produced per batch, in yd^3 (m^3),

Yd = Theoretical Yield (yd^3) (m^3)

NOTE: A value for Ry greater than 1.00 indicates an excess of concrete being produced, while a value less than 1.00 indicates the batch to be "short" of its designed volume.

Sec. 410.05 Significance of Yield

Should the actual yield of concrete at the completion of any day's run vary by more than 2 percent from the theoretical yield, the scales should be inspected immediately for error. Other causes of improper yields are incorrect pavement thickness, improper forming, too much water or aggregate per bag of cement, or incorrect amount of entrained air. In any event, the District Materials Engineer should be notified at once for approval before taking corrective measures.

SECTION 411 STRUCTURAL AND MISCELLANEOUS CONCRETE

Sec. 411.01 General

In order to ensure quality control as well as to determine various strengths of concrete, structural and miscellaneous fresh concrete is sampled in the field for compressive strength tests, in addition to air content, consistency, and other tests. Structural concrete is considered to be bridges, box culverts, and retaining walls, while miscellaneous concrete includes all concrete except pavement, prestressed, and structural. Foundations for overhead signs, signal poles, and lighting poles are structural concrete and must be tested at the same rate as other structural concrete. Control testing should be performed on each days placements by the contractor, to determine the strength is in accordance with specifications at the time of erection of the poles.

On concrete structures, the concrete is not in flexure as a beam, but in compression; hence, the need for determining the compressive strength. The sampling shall be conducted only by properly authorized and trained personnel. The necessity for properly preparing and caring for compressive strength test specimens must be stressed to the personnel involved. Concrete cylinders cast on the job are used for purposes of compressive strength tests, and at least 90 percent of the test specimens of each class of concrete for each project shall meet the minimum design strength requirements, or an investigation will be initiated by the District Materials Engineer.

Sec. 411.02 Compressive Strength Specimens

(a) General

Compressive strength specimens are to be made by casting fresh concrete in cylindrical molds. Records shall be kept of all tests of concrete mixes, in accordance with Paragraph (f) below.

(b) Sampling

Concrete for the test specimens shall be taken immediately before it is placed in the work, in accordance with AASHTO T141, or as modified herein. The member or section of the structure into which the concrete has been placed shall be noted clearly for future reference. THE SAMPLE OF CONCRETE FROM WHICH TEST SPECIMENS ARE MADE SHALL BE REPRESENTATIVE OF THE ENTIRE BATCH.

An air content and a consistency test, as outlined in Secs. 409 and 408 respectively, shall be made of the same batch of concrete from which the cylinder is cast, and the data recorded as for the other tests, with an identification number or description added.

(c) Molding and Curing

Molding and curing of the cylinder specimens shall be accomplished, as outlined in AASHTO T23, or as modified herein. Molds should not be left out in the hot sun before casting the specimens.

Molds shall be placed on a rigid horizontal surface free from vibration and other disturbances. After the casting of the cylinders and during the first 24 hours, all test specimens shall be stored under conditions that maintain the temperature immediately adjacent to the specimens in the range of 60^{o} to 80^{o}F (16^{o} to 27^{o} C), and prevent loss of moisture from the specimens. Wet burlap shall be placed over the specimens to maintain the temperature and to prevent loss of moisture. After the burlap has been moistened and placed over the cylinders, moisture proof material (such as polyethylene or plastic) shall be placed over the cylinders. Care shall be taken to see that this is sealed by use of a string, rubber band, or other device. The cylinders shall be protected from heat and cold during the entire field storage period.

Cylinders used for quality (acceptance) shall be submitted to the Laboratory as soon as possible after the first 24 hours. It is important that these cylinders be placed in the temperature-humidity controlled room when the cylinders are at a very early age.

Cylinders used for early form removal (control) specimens shall be removed from the molds at the end of 24 hours and placed adjacent to or near the concrete structure. These cylinders shall be cured at the same temperature and moisture condition as the structure. These specimens shall be submitted to the Laboratory for test on the day prior to the desired testing date. Do not send the cylinder several days prior to the specified testing date. The Laboratory has no way of duplicating the same cure as that being applied to the structure. If these cylinders are tested on portable compression testing machines, see further details in Secs. 401.01(b) and 411.02(e) herein.

It is important to recognize the difference in these two types of specimens. The quality cylinder represents the potential that the concrete possesses. It does not represent the strength of the concrete in the structure. The latter has not received the ideal temperature and humidity needed for optimum strengths. Therefore, one should keep this in mind when evaluating the two concretes. If one wishes to have data more nearly representing the strength of the concrete in the structure, additional cylinders should be cast and cured with the in-place concrete. However, the specification requirement is the design or potential strength and effectively there is no in-place strength requirement.

(d) Frequency of Sampling

For structural concrete, one set of 3 cylinders shall be made for each 100 cubic yards (50 cubic meters) of concrete placed, with a minimum of 2 sets of 3 cylinders each per structure per class of concrete. The 3 cylinders in a set are to be made from the same batch of concrete. On exceptionally large structures involving an unusually large amount of concrete, permission may be granted by the State Materials Engineer, upon written request, to reduce the number of cylinders required per structure.

For miscellaneous concrete, one set of 3 cylinders shall be made for each 250 cubic yards (200 cubic meters), with a minimum of one set of 3 cylinders per project. In the case of projects containing less than 50 cubic yards (38 cubic meters) of miscellaneous concrete, the District Materials Engineer may waive the requirement for compressive specimens, provided that this is documented in project records. Cylinder tests for the same class of concrete for other projects being supplied on the same day from the same plant may also be used to satisfy the testing requirement.

Concrete for rest area and landscape contracts will be tested the same as outlined above.

(e) Testing

Compressive strength specimens shall be prepared for testing in the Laboratory, in accordance with AASHTO T22, or as modified herein.

In no case shall one cylinder be tested and that result used. All tests shall be a minimum of 2 specimens. In the case of those cylinders tested on the portable compression testing machines, as outlined in Sec. 10l.01(b), it will not be necessary to cap these specimens in the normal manner. The use of cardboards furnished by the Department will be satisfactory in lieu of capping. The Inspector will operate this machine and record the test results in the project diary. No test report is written. The Inspector will also be responsible for transporting the control cylinders to the compression testing machine at the request of the Contractor. The rate of application of the load by the compression machines shall be between 20 and 50 psi per second (0.14 and 0.34 MPa per second), which is approximately 450 pounds (2000 Newtons) load per second on 4 in. (100 mm) diameter cylinders and approximately 1000 pounds (4500 Newtons) load per second on 6 in. (150 mm) diameter cylinders. The total load is divided by the area of the cylinder to obtain the strength in psi (Pa). The area of a 4 in. (100 mm) diameter cylinder is 12.56 sq. in.(0.0081 m^2), and the area of a 6 in. (150 mm) diameter cylinder is 28.27 sq. in. (0.0182 m^2). Any strength result of an individual specimen which deviates more than 500 psi (3.5 MPa) from the average of the 3 will be discarded and the average of the remaining 2 will be considered the test result. Should 2 specimens deviate more than 500 psi (3.5 MPa), the test will be considered invalid and a report made to that effect.

Except when high-early strength concrete is specified, compressive strength testing will be performed at 28 days. For construction specifying high-early strength concrete, the compressive strength testing will be performed at 7 days unless otherwise specified.

Plastic properties of concrete will be as specified for the class of concrete delivered, even if it is a higher class than specified. The compressive strength will be as specified for the class of concrete specified for a particular element of construction, even if a higher class of concrete is delivered. Form removal strength will be based on the specified class of concrete, not on the delivered class of concrete. A note should be added to the TL-13 noting the designer specified class of the concrete.

If low strength results are obtained at 7 days or at 28 days, this will be considered a failure and steps outlined in Sec. 415.01(g) will be taken.

(f) Reports

Field data for concrete cylinders will be reported on Forms TL-13 or TL-13A and TL-28A (computerized batch input form) (ready-mix concrete), and laboratory tests will be reported on Form TL-26 (TL-26B, if computerized cylinder test report form), as outlined in Sec. 800. (Note exceptions for cylinders tested on portable compression testing machines, as outlined in Paragraph (e) above.)

Recorded data for compressive strength specimens shall include, but not be limited to, the following details:

(1) Date and time of day.

(2) Class of concrete.

(3) Percent of free moisture in coarse aggregate.

(4) Percent of free moisture in fine aggregate.
(5) Water-cement (W/C) ratio (lbs. water per lb. cement) (kg water per kg cement).
(6) Cement content (lbs. of cement per cu. yd.) (kg of cement per m^3).
(7) Percent of entrained air.

(8) Amount of slump.
(9) Temperature of plastic concrete.
(10) Average air temperature at time of casting.
(11) Average temperature during curing.
(12) Location of point of deposit in the structure.
(13) Types and amounts of admixtures.

SECTION 412 PAVEMENT CONCRETE

Sec. 412.01 General

Concrete pavements depend upon their flexural strength, not their compressive strength, to carry the loads to which they are subjected. In order to determine the time at which pavement concrete has attained sufficient strength to sustain ordinary traffic, and therefore may be opened for use, beam tests are utilized. In addition, air content, consistency, and other tests are performed.

In addition to flexural strength specimens, concrete pavement will also be checked for depth, by drilling cores from the completed pavement. This drilling will be performed by the District Materials Laboratory.

Sec. 412.02 Flexural Strength Specimens

Flexural strength specimens are to be made by casting fresh concrete in beam molds. Records shall be kept of all concrete beams cast on pavement jobs, in accordance with Paragraph (e) below.

(a) Sampling

Concrete for the test specimens shall be sampled from the batch immediately after it is deposited on the subgrade, in accordance with AASHTO T141, or as modified herein.

An air content and a consistency test, as outlined in Secs. 409 and 408 respectively, shall be made of the same batch of concrete from which the flexural beam is cast, and the data recorded as for the other tests.

(b) Molding and Curing

Molding and curing of the flexural specimens shall be conducted, as outlined in AASHTO T23, or as modified herein.

Molds for the casting of beams for test purposes are supplied by the District Materials Engineer on each concrete pavement construction project. These molds are designed to give a beam specimen of such length that, when necessary, 2 determinations of strength can be made on each. The dimensions of the beam are 6" x 6" x 40" (150 mm x 150 mm x 1 mm), and an accurate determination of the area of the cross section shall be made at the point of failure after each test.

The test specimen shall be made as quickly as possible, and the exposed surface shall be treated for the first 24 hours in exactly the same manner as the pavement surface. At the end of 24 hours, or longer if temperature conditions require, the beam shall be removed carefully from the form, marked for identification, and buried flush with the surface of the soil. The top surface shall continue to be cured in the same manner as the pavement surface, until the Inspector is ready to determine the beam strength or modulus of rupture.

(c) Frequency of Sampling

A minimum of at least one complete beam shall be cast for each day's concreting operation.

(d) Testing

Flexural strength of the test specimens shall be determined, as outlined in AASHTO T177, or as modified herein.

In cool weather, due to the retarding effect of lower temperature on the strength of the concrete, the first break should be made on the test specimen about 2 weeks after casting. In summer, with prevailing temperatures around 90°F. (30°C), the first break of the beam may be made in one week. If the modulus of rupture is not as great as required by the specification, another determination should be made several days later, on the remainder of the specimen. Experience will soon indicate at what age the beam will probably have reached or exceeded the required modulus of rupture, and it will rarely be necessary to make a second test on the same beam.

The apparatus furnished for the beam test is composed of a simple hydraulic jack and a yoke to restrain the upward movement of the jack, for the purpose of applying the maximum stress on the center of the specimen along a line at right angles to its axis. The jack is equipped with a gage having a free hand to record the maximum load. A pencil line is drawn 13 in. (0.33 m) from one end of the beam, across one side, at right angles to its axis. The beam, with the pencil mark up, is laid on the 2 half-round bearings of the frame, allowing one inch (30 mm) overhang at one end. The jack is placed on the beam, its half-round bearing directly on the pencil line, which should be exactly under the center line of the yoke. The head of the jack is unscrewed until it rests firmly against the underside of the yoke. The load is applied by operating the jack at not more than 900 lbs. (4000 N) (gage reading) per minute, after passing the 1800 lb. (8000 N) load reading. Up to 1800 (8000 N), the load may be applied more rapidly. As the distance between the beam supports is 24 in. (0.60 m), the modulus of rupture of the 6 in. (150 mm) square beam, in lbs. per sq. in. (MPa), will equal 1/6 of the gage reading at the breaking load, in accordance with the formula for modulus of rupture with center point loading as follows:

$$\text{Modulus of Rupture, in psi} = \frac{3WL}{2bd^2}$$

Where: W = Maximum indicated load, in lbs.,

L = Distance between supports, in in., and

b & d = Breadth and depth of beam, in in.

With a 6" x 6" x 40" beam, this formula resolves to: $\frac{72W}{432} = \frac{W}{6}$

Therefore, 1/6 of the gage reading equals the modulus of rupture of the tested specimen, in lbs. per sq. in.

$$\textit{Modulus of Rupture, in MPa} = \frac{3WL}{2bd^2 * 10^6}$$

Where: W = Maximum indicated load, in N

L = Distance between supports, in m

b & d = Breadth and depth of beam, in m

With a 150 mm x 150 mm by 1 m beam, this formula resolves to: $\frac{3*.6W}{2*.15*.15^2*10^6} = \frac{W}{3750}$

Therefore, 1/3750 of the gage reading equals the modulus of rupture of the tested specimen, in MPa.

(e) Reports

Field data for concrete beams will be recorded and maintained in project records. The information shall include, but not be limited to, the following details:

(l) Date beam was cast.

(2) Class of concrete.

(3) Percent of free moisture in coarse aggregate.

(4) Percent of free moisture in fine aggregate.

(5) Water-cement (W/C) ratio (lbs. water per lb. cement)(kg water per kg cement).

(6) Cement content (lbs. of cement per cu. yd.)(kg of cement per m^3).

(7) Percent of entrained air.

(8) Amount of slump.

(9) Temperature of plastic concrete.

(10) Average air temperature at time of casting.

(11) Average temperature during curing.

(12) Type of curing.

(13) Types and amounts of admixtures.

(14) Age at time of test.

(15) Modulus of rupture.

(16) Station number or location.

Sec. 412.03 Depth Tests

Job acceptance depth tests of concrete pavements will be conducted, as outlined in VTM-26. The depths of the drilled cores will be reported on Form TL-105, as outlined in Sec. 800. See also Sec. 401.01(e) for additional details of coring equipment.

SECTION 413 PRESTRESSED CONCRETE

Sec. 413.01 General

Prestressed concrete is utilized in beams, piles, and deck panels for bridges and buildings. These members are normally fabricated in a precasting concrete plant. The inspection of this work is the responsibility of the prestressed concrete Plant Inspector, who works under the direct supervision of the District Materials Engineer. Technical assistance, and the supervision of commercial inspection is the responsibility of the Materials Division. The nature of the construction requires absolute control of uniformity in all operations by the Fabricator, in order that each member will be identical in all respects with every other similar member in any one bridge. All phases of fabrication will be monitored as outlined in this section by the Inspector on a random basis, as directed by the District Materials Engineer. The Materials Division is to be notified when any discrepancies are found in any part of the stressing, forming, casting, curing, or handling operations.

Sec. 413.02 Pretensioning Strand and Use of Typical Curve

Prior to casting concrete in the prestress plant, seven-wire, prestressing, steel strand must be located properly along the casting bed, anchored at each end with strand chucks or otherwise suitable anchors and tensioned to the required load as shown on the bridge drawings. There must be one strand located and threaded through the various templates and bulkheads in each position shown on the approved bridge drawings. The location and total number of strands on the bed must be perfectly matched with that as shown on the bridge drawings for any particular unit.

With each size strand supplied for use in a prestress plant by a strand Producer, a Manufacturer's stress-strain curve will also be supplied upon request. When computing the elongations required for the stressing bed, use ONLY the curve supplied for the particular SIZE and MAKE strand which is being tensioned. Strand must be sampled at the prestress yard, as outlined in Sec. 204.32(d).

Elongations, pressure gage readings, and applicable allowances for stress corrections will be computed by the fabricator in accordance with PCI Manual for Quality Control (MNL-116). These computations will be checked for accuracy by the inspector before the stressing operation begins.

Sec. 413.03 Forming

Next to securing quality concrete and proper prestress, the most important duty of the Plant Inspector is that of checking accurate lines and dimensions of the precast bridge units. These must be in strict accordance with bridge plan shapes and dimensions, and very little tolerance is allowed in any form work. Vertical, horizontal, and transverse dimensions of all bridge units are extremely critical, and must be checked and rechecked during and after the forming stage. Precast units which do not meet the requirements of good finish, good workmanship, and proper dimension and alignment will be promptly rejected by the Plant Inspector.

Casting beds should be set in proper alignment with the use of an instrument. Forms which are out of true alignment must be straightened before continuing with the forming operation.

The joints between form sections must also be carefully examined often to ensure a smooth, tight surface. A loose joint will allow excessive grout loss. An uneven, rough joint will restrict the movement of the precast unit during shrinkage or stress release, thereby causing a vertical crack in the side surface of the unit, or a transverse crack in the bottom surface of the unit.

The edges of the forms, especially along the chamfer strip, must be examined repeatedly by the Inspector to ensure that grout does not build-up under the strip, thereby springing the form out of alignment and causing uneven edges and surfaces in precast units. This can also cause excessive grout loss between the side and bottom forms. Side forms must be secured tightly at the bottom as well as at the top to prevent grout loss, and to prevent bulging, uneven bridge members.

Any internal forming such as reinforcing steel, strand, hollow voids, inserts, etc., must be properly secured and in place in accordance with bridge plans. If necessary, strand must be properly located with spacers. The height of each row of strand must be checked by the Inspector, not only at the end bulkhead forms, but also at midspan of members where sagging is most likely to occur. Strand is not to be used as an anchor for tying other internal formwork in place. This causes the strand to sag under the additional weight, or to float after concrete is cast in the forms, thereby moving it out of its proper position.

Hollow voids should be anchored firmly and securely in place with bracing from above, which is in turn anchored to the side forms.

The end bulkheads occasionally are set 1/8 to 1/2 inch (3 to 13 mm) longer than the required length of the bridge member. This allows for the shortening of the unit from shrinkage and stress release. The exact amount must be determined by the Producer and checked by the Inspector from trial and error on previous castings. Usually the longer the bridge member, the more the shortening will be, and the more the allowance required in forming.

Extreme care must be exercised by the Fabricator to ensure that the prestress strands do not become oily or dirty from handling and forming. Forms must be properly oiled to insure a smooth finish, but the oiling must be done in such a way as to prevent the oil from touching the strands.

If strands become oily, the Inspector must see that they are properly cleaned before depositing concrete in the forms.

Sec. 413.04 Sampling and Control of Concreting Operations

The control of prestressed concrete batching, mixing, and placing is the same as for other concrete operations. It must be handled with the same caution and respect and it must be very carefully monitored to ensure absolute uniformity from one batch to the next, and from one precast unit to the next in the same casting operation. All concrete testing will be performed by the Producer, as required in Sec. 405.04 of the Road and Bridge Specifications.

The procedures outlined elsewhere in Sec. 400 herein for controlling concreting operations apply equally as well to prestressed concrete. The proper methods of sampling concrete for air content, consistency, compressive strength, and yield, as well as aggregate for moisture content and grading, are outlined respectively in Secs. 409, 408, 411.02(b), 410.03, 402.02, and 204.02(c)(1).

The air content and consistency shall be determined on each batch sampled for compressive strength cylinders. Only the pressure air meter is to be used.

In the control of prestressed concrete, the compressive strength cylinders are used to satisfy 2 essential control requirements; (1) concrete in the precast unit must attain a required strength before the stress in the strands may be transferred to the concrete, and (2) the design strength must be met before the member may be handled (except moving to storage), or released for shipment. These cylinders will be tested at the plant on an approved compression machine which is calibrated at least annually.

To properly control the stress release and handling of the members, a minimum of 2 clusters, placed at quarter points of the casting bed, each consisting of a minimum of four (4) 6" x 12" (150 mm x 300 mm) or six (6) 4" x 8" (100 mm x 200 mm) cylinders will be made and cured under the same conditions as the members. These cylinders should be tested in accordance with, and meet the requirements of, Sec. 405.04 of the Road and Bridge Specifications.

Cylinders, that have been cured with bridge members and are to be used for shipping strengths, must NOT be moist cured afterwards. The cylinders must be tested in as nearly an identical condition as that in which the prestressed unit exists until the time of test. The cylinders shall be tested in accordance with AASHTO T22, with the above noted exception.

Sec. 413.05 Curing, Moist and Steam

If the Fabricator has elected to use moist curing as a curing medium for the prestressed concrete units, the suggestions outlined in Sec. 407 herein and Sec. 405.05(f) of the Road and Bridge Specifications, should be followed.

If steam curing is used, the procedure outlined in Sec. 405.05(f) of the Road and Bridge Specifications shall be followed. In particular, special attention should be paid to proper curing, maintaining proper delay and preventing evaporation of needed moisture, determining initial set, maintaining a tightly closed curing chamber, proper rate of temperature rise and uniform bed temperature, and placement of cylinders and recording thermometers in the curing chamber. Open steam line jets must not be directed towards the steel forms or towards the cylinder molds under the covering. Disregarding this can result in local "hot" spots developing in the concrete, which can lower the compressive strength.

Prior to using thermometers, a calibration should be made. This may be accomplished by inserting all recording tips in a pan of water at the same time to ensure that all thermometers show the same temperature on each chart. A small previously calibrated dial thermometer may be used at the same time, to determine that the other thermometers are recording accurately.

Sec. 413.06 Stress Release

When the compressive strength required for stress release has been attained, then the forms are loosened to prevent any restriction of movement, and the stress is released before the concrete has been allowed to cool. If the concrete cools prior to release, vertical and transverse cooling cracks may occur in the bridge members where the concrete tends to pull apart. All cooling must be gradual to prevent thermal shock in the member. Just prior to the stress release, the Producer must make a thorough visual inspection of all members to see that structural or shrinkage cracks are not present in the concrete surface, and to ensure that there are no obstructions within the formwork to restrict movement of the members on the bed.

It is very important that approved procedures for stress release of strand patterns be followed carefully, particularly where deflected strands are used. Procedures for stress release shall be followed, as outlined in the Road and Bridge Specifications or reviewed shop drawings.

Sec. 413.07 Handling Precast Units

Provided that the compressive strength of the concrete, as determined by the method outlined in Sec. 413.04, meets the requirements of the specifications, the prestressed concrete bridge members may be handled for yard storage or for shipment to the project.

All units must be handled ONLY at the pick-up points using hooks or other devices embedded in the concrete specifically for that purpose. For beams, this will normally be close to the ends on the top surface in the area approximately over the bearing surface. Beams must be picked up in a horizontal, upright, level position. If beams are to remain in storage, or are to be shipped to the job site, they should rest on perfectly flat and level supports which give a complete and flush bearing surface. The beams should rest in an upright, level position, and there MUST NOT be any support at any other points but the bearing area. When it is required to move the supports in cases of plant erection of beams or when it is necessary to perform any work on bearing surfaces of beams, the supports should be moved ahead of or behind the bearing areas only by an amount necessary to gain access to the bearing area and only for a temporary period of time necessary to perform the work.

Piles should be marked in such a way that the pick-up points, as shown on bridge plans, are clear and unmistakable. Piles should be handled and supported ONLY at the correct pick-up points.

After stress release, and sometime prior to the release of bridge members for shipment, visual inspection will be made of all units for cracks, improper alignment, incorrect dimensions, excessive camber or sag, improper shapes, honeycomb and any other discrepancies which would cause the member to be unsatisfactory for use. All measurements are preferably made when the units are removed from the casting bed. Discrepancies of any nature found in the bridge members should be reported immediately to the Materials Division. If deemed necessary by the Materials Engineer, an inspection will be made to determine whether or not the member may be satisfactory for use.

Sec. 413.08 Reports

Reports of inspection and shipping shall be made out on Form TL-109, as outlined in Sec. 800. A materials notebook shall be kept by the Plant Inspector for each project, in accordance with Sec. 800. The Producer shall maintain records of production including tensioning operation, curing temperatures, and concrete test results. These records should be reviewed for compliance with the applicable specifications by the Plant Inspector before the members are released at the plant.

General duties of the Plant Inspector in addition to those outlined above shall be in accordance with Sec. 109.

Sec. 413.09 Shop Drawings and Special Requests

These will be handled in accordance with Sec. 115, Control of Work, in the Road and Bridge Specifications.

Sec. 413.10 Summary of General Outline of Duties of Prestressed Plant Inspector

(a) Preliminary

(1) Check shop drawings thoroughly to ensure that they agree with bridge plans and special provisions.

(2) Check storage of reinforcing steel, strand, and other components of members, such as form void tubes, to ensure that storage is adequate to provide protection from contamination and weather.

(3) The Producer will run levels on the pallet initially and each time the pallet is removed and replaced. Also, straight edge the pallet at location which will form the bearing areas of proposed beams before each stressing operation. The Inspector will observe these operations periodically.

(4) See that all materials to be used in the fabrication of prestressed members are previously tested or certified, including gauges.

(5) See that all proposed modifications of the members have been approved in writing.

(b) Stressing Operation

(1) Check Producer's elongation calculation. (If calculations do not agree within 1/8 inch (3 mm), both should recalculate).

(2) See that strand number and placement is correct, as well as condition (cleanliness, rust, etc.), before application of initial tension.

(3) Check the application of initial tension to ensure that the load is uniform on all strand.

(4) Check for twisted strands or strand which appears to be slack. Retension the strands which are twisted or on which the tension is doubtful.

(5) Observe the stressing operations to ensure that the elongation is applied correctly, and check the load as indicated by the gauges against elongation.

(6) Check for broken wires on strand. Allow no more than one (1) broken wire per strand. (Provided this is not more than 2% of the total number of wires).

(7) When stressing, especially draped strand, make sure that there is nothing binding the strand thereby resulting in a non-uniform stressing condition throughout the length of the bed.

(c) Forming Operation

(1) Check bulkheads for proper location to obtain desired length of member and for proper plumb, batter, skew, etc., of the ends.

(2) Check placement of reinforcing steel, inserts, etc., to ensure that they are placed in strict accordance with the bridge plans or standard.

(3) Check side form and pallet for smoothness, proper fit at joints, and alignment.

(4) If form voids are used, make certain they are securely tied in place before casting operation begins.

(d) Casting Operation

(1) Observe concrete batches to ensure that uniform concrete is being obtained throughout the pour.

(2) Observe for displacement of reinforcing steel, inserts, etc., during placement and vibration of the concrete.

(3) When form voids are used, watch to see that they do not float upward, move laterally or longitudinally during placement, and that the general workmanship is good.

(4) Observe air content and slump tests.

(e) Steaming Operation

(1) Observe preset time, the period between the completion of the pour and the introduction of the steam to the bed. Penetration Resistance test of 500 psi (3.5 MPa) may be used in lieu of preset delay period.

(2) Observe the calibration of recording thermometers periodically.

(3) Make periodic checks to ensure that the temperature is uniform along the length of the bed and to either side of the bed

(4) Review curing temperature charts for rate of temperature rise, curing temperature, and curing time to ensure that it meets Sec. 405 of the Road and Bridge Specification.

(f) Detensioning Operation

(1) Observe concrete cylinder compressive strength test for detensioning on a random basis.

(2) Observe detensioning procedures periodically to ensure that Road and Bridge Specifications, Sec. 405, is being met.

(g) Storage and Handling

(1) Observe the operation of lifting and transporting the members from the beds to the storage area, and to barge or truck.

(2) Visit the storage area periodically to observe the condition of the members and their supports.

(h) Plant Erection

(1) Check the difference in elevation of the machined steel bearing surfaces.

(2) Check the machined steel bearing surface with a level.

(3) Observe the mixing of the epoxy mortar.

(4) Observe the placing of the beam on the machined steel bearing surface.

(5) Check the end of the beam for horizontal and vertical skew.

(6) Check the epoxy wedge after removal from the bearing surface.

(7) Check the application of the roughened surface to the epoxy wedge.

(i) Shipping

(1) Check and record length, camber, and horizontal alignment of the beams prior to shipping.

(2) Ensure that the required design compressive strengths have been met.

(3) Check the support point for members on the barge or truck.

(4) Record identification number of member and stamp the member with the VDOT seal.

SECTION 414 OVERLAY CONCRETE

Sec. 414.01 General

Overlay concretes are not designed to increase the load-carrying capacity of the existing concrete. There are several reasons for placing an overlay. One is to remove approximately 1½ ″ (38 mm) of chloride contaminated surface concrete. Another is to reduce corrosion and protect aging, existing concrete roads and bridges from the harmful effects of salt, chlorides, and other roadway chemicals. It is easier for these chemicals to penetrate older, more permeable concrete and the overlay acts as a covering system to provide an extra layer of protection. An overlay can also be used to improve the ride quality of the bridge surface.

The two most common types of overlays are latex and silica fume concrete. The silica fume concrete may be batched at a ready-mix plant and shipped to the site in transit mix trucks in a similar fashion to structural concrete. The latex modified concrete is usually batched on site with the aid of a mobile mixer. In both cases it may be necessary to open the roadway to traffic as quickly as possible. In order to determine when the concrete overlay has sufficient strength to sustain ordinary traffic, and therefore may be opened for use, cylinder compressive strength tests are utilized. In addition, air content, consistency and other tests are performed.

Sec. 414.02 Mobile Mixer Calibration – Latex Modified Concrete

For latex modified concrete overlays the use of a calibrated mobile mixer is required. Each mixer must be individually calibrated. In addition, they must be recalibrated every 6 months thereafter, and after any change in materials including a change in source. A mixer that is calibrated and accepted in one district may be accepted in another at the discretion of the District Materials Engineer, provided the same materials are being used.

The calibration process is based on an approved mix design submitted by the contractor for the locally selected aggregates in Saturated Surface Dry (SSD) condition. The dry weight ratio of cement/fine aggregate/coarse aggregate in the SSD condition is approximately 1/2.5/2 with a latex modifier content of 3.5 gallons (13.25 L) per bag. The calibration counts are based on the discharge time for one 94 lb. (50 kg) bag of cement. Check that all scales and instruments used for weighing are approved and have current calibrations. Payment will be based upon the total number of calibrated counts. A recording meter, visible at all times and equipped with a ticket printout, should indicate the calibrated measurement.

The following data and calculations should be recorded on the worksheet. (See Appendix IV-E-1)

(a) Cement

The first step in the calibration procedure is to determine the amount of time and counts it takes to discharge 1 bag = 94 lbs. (50 kg) of cement. Select a container that can suitably hold the 94 lbs. (50 kg) of cement and determine the weight of the container when empty. Place the container under the chute of the mobile mixer and discharge an estimated 94 lbs. (50 kg) of cement while noting the meter count and the time in seconds. Weigh the full container and determine the weight of the cement only. If the cement weight is within tolerance of +4% (94 to 98 lbs) (50 to 52 kg), then record the noted time and count data on the calibration worksheet. If it is not within tolerance, then the data is invalid and shouldn't be recorded. This procedure must be repeated until 5 acceptable results are recorded.

Next, total the weight, time, and count columns.

The (total counts)/(total weight) gives the average number of counts per lb. (kg) of cement. This factor x 94 lbs. (50 kg) yields the calibrated cement meter count for one 94 lb. (50 kg) bag of cement. Record this result on the worksheet.

The (total time)/(total weight) gives the average discharge time per lb. (kg) of cement. This factor x 94 lbs. (50 kg) yields the calibrated time to discharge one 94 lb. (50 kg) bag of cement. Record this result on the worksheet.

Note that the calibration data found in this section is based upon 1 bag of cement. It will be necessary to adjust the results to determine the total counts needed when batching for a one yd^3 (one m^3) mix. This is done by multiplying the above count for one bag of cement by the number of bags required in a one yd^3(one m^3) mix. VDOT specifications require that a one yd^3 (one m^3) mix contain a minimum of seven bags (eight bags for one m^3) of cement. Therefore, the number of bags shown on the mix design (typically 7) x calibrated count for one bag (from above) = the total number of counts to produce one yd^3(one m^3). This value is recorded on the worksheet to the nearest whole number.

(b) Fine Aggregate

All calculations are based on fine aggregate weight in the SSD condition, which must be adjusted using the actual moisture content. The weight of sand in the SSD condition is taken from the approved VDOT mix design. However, this value must be adjusted in the following manner: Divide the sand weight taken from the approved design by the number of bags (typically 7) in the design mix. This yields the (sand weight)/(bag of cement) in SSD condition. If the sand is not SSD then the weight must be adjusted using the appropriate free moisture content. The final value is the target sand weight for the calibration process. It is the weight that must be discharged in the calibrated time found in the previous paragraph (a). However, to ease the process, since this weight would be difficult to secure and move, it is permissible to use ½ the target weight of the sand and ½ the calibrated discharge time while calibrating.

The next step is to adjust the sand gate using the sand dial. The purpose is to produce a rate that results in the required weight of sand discharging in the required discharge time. After the dial is set, discharge the sand for the calibrated time (or ½ time if used) into a suitable container and determine the weight of the sand alone. If the weight is within tolerance (±2%) of the previously calculated target weight, then record the dial setting and the lbs. (kg) of sand on the calibration sheet. If the weight is not within tolerance, then discard the results and choose a new dial setting accordingly. Repeat the process at the dial setting until five consecutive, suitable readings are recorded.

(c) Coarse Aggregate

All calculations are based on the coarse aggregate weight in the SSD condition, which must be adjusted using the moisture content. The weight of stone in the SSD condition is taken from an approved VDOT mix design. However, this value must be corrected in the following manner: Divide the stone weight taken from the approved design by the number of bags (typically 7) in the design mix. This yields the (stone weight)/(bag of cement) in SSD condition. If the stone is not SSD then the weight must be corrected using the appropriate moisture content. The final value is the target stone weight for the calibration process. It is the weight that must be discharged in the calibrated time found in paragraph (a). However it is permissible to use ½ the target weight of the stone and ½ the calibrated discharge time for the same reasons as stated in the fine aggregate section.

The next step is to adjust the stone gate using the stone dial. The purpose is to produce a rate that results in the required weight of stone discharging in the required discharge time. After setting the dial on the first estimate, discharge the stone for the calibrated time (or ½ time if used) into a suitable container and determine the weight of the stone alone. If the weight is within tolerance (±2%) of the previously calculated target weight, then record the dial setting and the lbs. (kg) of stone on the calibration worksheet. If the weight is not within tolerance, then discard the results and choose a new dial setting accordingly. Repeat the process at the dial setting until five consecutive, suitable readings are recorded.

(d) Latex

A latex sample must be taken on the project and submitted to the Materials section for each district per contractor per year. The total gallons (liters) of latex required can be found on the approved mix design. Divide this value by the number of cement bags (typically 7), to determine the latex (in gallons (liters)) per bag of cement. This value needs to be converted to determine the latex (in lbs. (kg)) per bag of cement so that it can be weighed out. The conversion factor is the specific gravity of the latex multiplied by 8.33 lbs/gal (4.84 kg/L). The specific gravity can be found on the Materials Safety Data Sheet (MSDS) for the latex that is being used. The conversion factor is then multiplied by the amount of latex (in gallons (liters)/bag) to determine the weight of latex (in lbs (kg).). The resulting value for latex in lbs. (kg) is the target weight that must be used in the calibration process.

The next step is to adjust the flow setting to the best estimate of what will be necessary. After setting the flow rate, discharge the latex for the calibrated time found in paragraph (a) into a suitable container and determine the weight of the latex. If the weight is within the tolerance for latex (±1%), then record the flow setting and the weight of the latex. If it is not within tolerance, discard the results and adjust the dial setting accordingly. Repeat the process at the dial setting until five consecutive, suitable readings are recorded.

(e) Water

The total gallons (L) of water required can be found on the approved mix design. Divide this number by the number of cement bags (typically 7), to determine the water in gallons (L) per bag of cement. It is important to note that this value must be adjusted based on the free moisture that was found in the aggregates in paragraphs b and c. The amount of water must also be adjusted based on the water content of the latex mixture. Once the final, adjusted value has been determined, it needs to be multiplied by a factor of 8.33 lbs./gal (4.84 kg/L) to determine the water in lbs. (kg) per bag of cement so that it can be weighed out. This value of water in lbs. (kg) is the target weight to be used in the calibration process.

The next step is to adjust the flow setting to the best estimate of what will be necessary. After setting the flow rate, discharge the water for the calibrated time found in paragraph (a) into a suitable container and determine the weight of the water. If the weight is within the tolerance for water (±1%), then record the flow setting and the weight of the water. If it is not within tolerance, discard the results and adjust the dial setting accordingly. Repeat the process at the dial setting until five acceptable readings are recorded.

(f) Yield Test

There shall be one yield test per truck per day of batching. Also a yield test should be performed by the Contractor prior to deck placement for each mixing unit, when each unit is moved from the job site for recharging, when the source of stockpiled materials is changed and when there is reason to believe the calibration may be erroneous. The box must be built to a volume of ¼ yd^3 (0.20 m^3) A common set of box dimensions is 3′∗ 3′∗ 9″ (1.0 m* 1.0 m * 0.20m). The first step in the process is to batch a load of concrete using the previously determined calibration settings and total counts.

Note that for anything other than a one yd^3(one m^3) batch, the total counts must be adjusted accordingly. For example, a ¼ yd^3 (0.25 m^3) batch would require ¼ the total counts. Calculate the adjusted total counts for the yield box being used and record the result on the bottom of the worksheet. See paragraph (a) on determining the total counts.

The box should then be completely filled with concrete while noting the total number of counts used. This value must be within ± 1% of the calibrated counts that was determined earlier. If it is within tolerance, then it becomes the new calibrated total count. If they still don't fall within the required range, the calibration process must be redone.

Sec. 414.03 Testing

(a) Latex Modified Concrete

1. General

Compressive strength specimens are to be made by casting fresh concrete in cylindrical molds. Records should be kept in accordance with paragraphs (b and f) below.

2. Sampling

Concrete for the test specimens should be taken immediately before placement begins or shortly thereafter. The sample from which test specimens are made should be representative of the entire batch.

Air content tests should be made by the pressure method in accordance with AASHTO T152. The frequency of tests is to be one per truck for each load of material it carries. In other words, a truck that finishes batching and is reloaded, must also be retested. The current air content requirements for latex can be found in Table II-17 of the VDOT Road and Bridge Specifications. Should a test on a batch reveal the concrete to be out of the specification range, the inspector should immediately perform a recheck on the same batch. If the retest confirms the results of the original test, then this should be cause for rejection.

Consistency tests should be made by the slump method in accordance with AASHTO T119, with the following additions. For the latex modified concrete, the slump should be measured approximately 4½ minutes after discharge from the mobile mixer. This is done in order to allow the cement in the mix to fully dampen. The only mixing of the concrete occurs in the augured trough, and this is not enough to fully wet the cement. The 4½ minute waiting period allows the water to blend throughout the mix and wet all of the cement. After this initial time period, the slump usually remains stable for approximately the next 20-30 minutes, during which time the concrete will have been consolidated, screeded, and finished. The frequency of consistency tests should be equivalent to the frequency of the air content tests. The current consistency requirements for latex modified concrete can be found in Table II-17 of the VDOT Road and Bridge Specifications.

It is the contractor's responsibility to make any acceptable corrections to adjust the air content or slump to within specification levels. These corrections are detailed in Sec 4xx.04 (b).

A yield test must also be performed during each day of overlay work to ensure that accurate payment is being made. Instructions on the yield test may be found in the previous section (4xx.02 (f)) on calibration for latex overlays.

3. Molding and Curing

Molding and curing of the cylinder specimens should be performed as outlined in AASHTO T23, or with the necessary modifications as noted in Sec 411.02 (c), with the following exceptions: the latex cylinders must be submerged for the balance of seven days after their arrival at the Laboratory and then air cured for the remainder of the 28 day curing period.

4. Frequency of Sampling

For latex modified concrete, one set of 5 cylinders must be taken for every day of placement with a minimum of one set per bridge. Any placement over 25 yd^3 (20 m^3) will require an additional set of cylinders at every 25 yd^3 (20 m^3).

5. Testing

Compressive strength specimens should be tested in accordance with Sec 411.02 (e). The additional 2 cylinders (from the set of 5) submitted to the Materials Division will be used for permeability testing.

6. Reports

It is the responsibility of the project inspector to ensure that field data for cylinders will be recorded on Forms TL-13 and TL-28A. Lab tests will be reported on TL-26.

(b) Silica Fume

1. General

Compressive strength specimens are to be made by casting fresh concrete in cylindrical molds. Records should be kept of all tests in accordance with paragraphs (b and f) below.

2. Sampling

Concrete for the test specimens should be taken immediately before placement begins. The sample from which test specimens are made should be representative of the entire batch. An air content and consistency test should be made from the same batch of concrete from which the cylinders are cast, and the data recorded as for the other tests.

Air content tests should be made by the pressure method in accordance with AASHTO T152. The frequency of tests is to be one for each load of concrete. The current air content requirements for silica fume can be found in Table II-17 of the VDOT Road and Bridge Specifications. Should a test on a batch reveal the concrete to be out of the specification range, the inspector should immediately perform a recheck on the same batch. If the retest confirms the results of the original test, then this should be cause for rejection.

Consistency tests should be made by the slump method in accordance with AASHTO T119. The frequency of consistency tests should be equivalent to the frequency of the air content tests. The current consistency requirements for silica fume can be found in Table II-17 of the VDOT Road and Bridge Specifications.

It is the contractor's responsibility to make any acceptable corrections to adjust the air content or slump to within specification levels. These corrections are detailed in Sec 4xx.04 (b).

3. Molding and Curing

Molding and curing of the cylinder specimens should be performed as outlined in AASHTO T23, or with the necessary modifications as noted in Sec 411.02 (c).

4. Frequency of Sampling

For a silica fume overlay, one set of 5 cylinders must be taken for every day of placement with a minimum of one set per bridge deck. Any placement over 25 yd^3 (20 m^3) will require an additional set of cylinders at every 25 yd^3(20 m^3).

5. Testing

Compressive strength specimens should be tested in accordance with Sec 411.02 (e). The additional 2 cylinders (from the set of 5) submitted to the Materials Division will be used for permeability testing.

6. Reports

It is the responsibility of the project inspector to ensure that field data for cylinders will be recorded on Forms TL-13 and TL-28A. Lab tests will be reported on TL-26

Sec. 414.04 Placement Procedures

A majority of the problems that occur with both latex and silica fume concretes are related to construction activities. Usually, the problems are caused by: 1) poor bonding that leads to delaminations; 2) lack of consolidation which leads to delaminations and high permeability; 3) and inadequate curing that leads to cracking and high permeability. The following procedures are designed to minimize the occurrence of these problems and apply to both latex and silica fume concretes unless otherwise noted.

(a) Surface Preparation

Within 24 hours immediately preceding the beginning of the overlay operations, the entire surface to be overlaid and the edge of previously placed overlay should be thoroughly cleaned. The surface of the base concrete should be cleaned using milling, shotblasting, waterblasting, sandblasting, or any combination of these methods. The cleansing should remove laitance, expose the surface coarse aggregate (minimum 25% of the surface area), and leave a rough surface texture. The purpose of these procedures is to establish a fresh fracture face on the area to be overlaid. A fresh, clean face on the aggregate is needed for proper bonding. Dust, contaminants and laitance, reduce the ability of the overlay to bond to the bridge deck.

The surface of the deck should be free of contaminants and should be thoroughly and continuously soaked at least one hour prior to the placement of the overlay. After wetting, the surface should be covered with plastic. At the time of the application of the bonding layer, the surface should be visibly moist but free of any standing water. Dry areas should be rewetted, and all standing water in depressions should be blown out with oil-free compressed air.

The bonding layer should consist of a portion of the concrete brushed onto the surface. Excess aggregate remaining after brushing should be removed. Care should be taken to ensure that all surfaces receive a thorough, even coating of mortar about 1/8 in. (3.175 mm) in thickness. The rate of progress should be such that the bonding layer does not become dry before the overlay is applied. This is usually a maximum of 3 to 5 ft. (0.9 to 1.5 m) in front of the placement of the overlay.

(b) Mix Adjustments

Latex - In the event of a low slump value, the addition of latex to the mix is acceptable, but under no circumstances should water in excess of the approved mix design be added to improve slump, workability or any other characteristics. In the case of a high slump value, it should be water and not latex, that is removed to adjust the slump to an acceptable level.

A low air content may be corrected by raising the height of the chute. This will increase the mix time and should force more air into the concrete. A high air content may be corrected through the use of a chemical defoamer. This agent will eliminate air bubbles in the mix.

Silica Fume - Addition of a High Range Water Reducing Admixture (HRWRA) at the plant enables the dispersion of cement and silica fume particles leading to improved properties. Thorough mixing is essential for uniformity. If HRWRA is also added at the job site, it should be dispensed by means of a wand so that HRWRA is directly placed on concrete. Mix a minimum of 70 revolutions to ensure complete mixing dispersion.

(c) Consolidation and Finishing

The finishing machine should be capable of forward and reverse motion under positive control. If travelling in reverse, the screed should clear the finished surface. The finishing machine should be equipped with an auger strike-off, a vibrating element with a minimum frequency of 3000 vpm, a roller, a pan float, and a burlap drag. The concrete should also be consolidated using surface type or immersion type vibrators in areas in which the vibrating element of the screed does not reach. This is to include both transverse and longitudinal joints. Immersion type vibrators shall also be used where the thickness exceeds 3″ (75 mm).

(d) Curing

The curing of the concrete should begin immediately after screeding and shall conform to current VDOT specifications. It is the contractor's responsibility to provide equipment for a check of the surface evaporation rate. The check should be made every hour and the results reported to the inspector. The nomograph for determining the surface evaporation rate can be found in the manual of instructions on page IV-C-1. If the evaporation rate is more than 0.10 lb/ft^2/hr (0.49 kg/m^2/hr), the potential for cracking is very high, and placement is not recommended. The contractor should ensure that crack free concrete will be provided based on this knowledge. If the prevailing conditions result in a rate higher than 0.05 lb/ft^2/hr (0.24 kg/m^2/hr), the contractor should use one or more fog misting devices, or other such necessary measures, to reduce the rate of evaporation from the concrete during placement. Fog misting should be maintained starting immediately after screeding and should continue over the screeded area until the wet burlap is placed. The wet burlap should be placed as soon as possible after the finishing operation, but no later than 20 minutes after the finishing is completed. Additional measures to reduce evaporation (wind screens, shading covers, cooling concrete, etc.) should be used at the option of the contractor. Wet burlap should be thoroughly saturated over its entire area, but should be drained of excess water.

(e) Limitations

Concrete temperature should not be more than 15° F (8° C) higher than the ambient air temperature during the placement operation. This is done to avoid temperature differentials that lead to higher evaporation rates and an increase in plastic shrinkage cracking. If the ambient air temperature falls below 50° F (10° C) during the curing period, insulating blankets or external heating should be used as necessary so that the concrete temperature is kept above 50° F (10° C).

All defective areas including, but not limited to delaminations, cracking, or lack of consolidation should be repaired or replaced at the contractor's expense as approved by the engineer.

SECTION 415 SUMMARY OF IMPORTANT FACTORS

To obtain uniformly high strength concrete, the large number of possible variables must be controlled within as narrow limits as practicable. The most important of these factors in concrete construction which must be kept as constant as possible are as follows:

(1) Constant weight of cement in each batch.

(2) Constant volume of water, and as little as possible to ensure workability.

(3) Constant weight and grading of both coarse and fine aggregates.

(4) Thorough mixing through time control.

(5) Maintenance of workability through consistency tests.

(6) Thorough compaction of concrete to reduce air and water voids.

(7) Prevention of segregation at all times.

(8) Proper wetting of subgrade and forms.

(9) Immediate protection and retention of water in concrete until sufficiently cured.

(10) In cold or hot weather, maintenance of concrete at the time of placing and during the curing thereafter at temperatures as specified in the Road and Bridge Specifications.

It is the duty of both the Inspector and the Producer to see that these requirements, after the mix has been adjusted to the specified slump, are maintained at a constant value throughout the job for each class of concrete used.

SECTION 416 UNIFORM GUIDE FOR CONCRETE CONTROL

The following section is intended as a guide for interpreting and administering the specifications for concrete. This guide is to be considered as a supplement to the control procedures previously outlined herein. It is not intended to relieve the Inspector of other duties required to obtain proper quality inspection of concrete.

Sec. 416.01 Responsibility of Materials Division

(a) Mix Design Approval

Concrete mix designs shall be approved or disapproved, as outlined in Secs. 106.01(c) and 800, prior to the start of concreting operations.

(b) Personnel Certification

The State Materials Engineer shall direct the administering of examinations and certifications of Batchers, Technicians, and Inspectors.

Written examinations shall be administered by the District Materials Engineers for certification of Department and Industry personnel in their respective Districts. The written examination shall be monitored by the District Materials Engineer or his assistant, and an accurate accounting of all examination papers shall be maintained.

Practical examinations shall be administered under the direction of the State Materials Engineer, assisted by qualified personnel of the District Materials Engineers' staffs.

All written and practical examinations shall be prepared, graded, and recorded under the direction of the State Materials Engineer.

Re-examination and re-certification will be required 4 years from the date the certificates are issued. The status of the certification for Inspector, Technician, and Batcher is valid only for the specific responsibilities and privileges granted to the bearer and appearing on the certificate issued. If at any time an Inspector, Technician, or Batcher is found incapable of performing duties as prescribed herein, he or she is not to be allowed to take part in the production of concrete being batched for State use. The certification issued shall be rendered invalid upon the recommendation of the District Materials Engineer.

(c) Supervision of Certified Concrete Inspectors

The District Materials Engineer/representative shall be responsible for specification compliance of (1) the condition, handling, storage, and proportioning of all material, (2), performance of control checks and tests at the batching plant by the Producer, (3) performance of acceptance tests at the point of discharge, and (4) the condition of all plant, trucking, and placing equipment. He shall train and supervise all Department personnel who are involved in any of the above areas of inspection at all batching operations.

(d) Duties of Inspectors at Point of Discharge

An Inspector shall be present at the job site during the discharge and placement of concrete to properly inspect these operations. The Department shall detect and reject, at the point of discharge, all concrete which fails to meet the range specified for consistency and air content. Concrete having an air content less than the minimum value specified is to be considered equally objectionable as concrete having an air content greater than the maximum value allowed.

Concrete shall be sampled and tested for consistency and air content in accordance with Secs. 408 and 409.

If, during discharge, the Inspector observes an appreciable increase in the consistency of the concrete, especially when the initial test revealed the consistency to be borderline, discharge shall be halted and a retest performed. The remainder of the load shall be rejected if the results of the test(s) fail to meet the allowable limits specified.

(e) Inspection of Plant, Equipment, and Personnel

(1) Initial Plant Inspection

A program of regular but unannounced inspection shall be scheduled and supervised by the District Materials Engineer at all hydraulic cement concrete plants supplying concrete for State work. This inspection shall be conducted at any plant initially setting up and starting production, and at least once per year thereafter or as required. The purpose of this inspection is to determine that the plant equipment and personnel meet specification requirements. A record shall be prepared on a check list type form of all items covered during the plant inspections by the District Concrete Technician. (See Appendix IV-A)

A personal contact should be made with each Producer who intends to furnish concrete and who has had compressive strength problems in the recent past and who, because of certain problems known to exist, is likely to experience low compressive strengths again. It should be determined in the contact the additional control procedures the Producer will institute in an effort to avoid such problems in the future.

(2) Regular or Routine Plant Inspection

In addition to the initial or annual inspections, a program of regular inspection of hydraulic cement concrete plants shall be conducted by personnel of the District Materials Engineer's staff and by Central Office Materials personnel. The inspections are to be completely unannounced and are to be conducted for the purpose of determining whether or not specifications and instructions are being followed by the Contractor and personnel in the production, sampling, testing, and inspection of hydraulic cement concrete.

The frequency of these latter plant inspections should be related to the overall quality of the plant equipment and competence of the plant personnel. Plants, that have a record of continually producing good materials and of being in excellent condition and manned by well trained personnel, might be inspected by the Materials Division Technician as seldom as once a year. However, plants with poor records should be inspected more often. Periodic inspection of all plants at the same frequency regardless of record is <u>not</u> recommended.

A plant inspection report is to be issued on the forms available for this purpose immediately upon completion of this inspection. The forms are to be completely filled out by the District or Central Office Materials Personnel conducting the inspection, noting any and all specification discrepancies and any corrective action taken by the inspection personnel. In addition to copies of the report retained for District use, a copy of plant inspection reports shall be forwarded to the State Materials Engineer. Unfamiliar Department and Industry personnel shall be requested to show evidence of their certification to visiting representatives of the Materials Division.

(3) Inspection of Testing Equipment and Procedures

Periodically, as conditions warrant, inspections are to be conducted by personnel from the District Materials Office of the calibration of plastic cement concrete testing equipment and the testing procedures of project personnel. The purpose of this inspection is to improve proficiency and attain uniformity in the use of the equipment throughout the State. An error in testing of plastic concrete may mean rejection of a large amount of material or acceptance of material that does not meet specifications.

An inspection report is to be issued on forms available for this purpose by the person conducting the inspection and signed by this person and the Inspector whose procedures have been checked. (See Appendix IV-B) Copies of the report are to be forwarded to the State Materials Engineer and the District Materials Engineer.

(f) Sampling and Inspection of Materials

The Producer shall state on the delivery ticket, accompanying each load, the class of concrete, and weight of cement, aggregate, water, and amount of admixture used in the batch at the time of batching.

The District Concrete Technician should periodically monitor the physical characteristics of materials in storage at the batching plant, as follows:

The cement shall be examined for hardened or hydrated cement lumps.

Coarse aggregate shall be inspected for particle coating, segregation, presence of organic and/or soft particles, aggregate in less than saturated surface-dry condition, and any other detrimental characteristics.

Fine aggregate shall be inspected for the presence of clay, presence of organic material, highly variable moisture condition, and any other detrimental characteristics.

Water shall be examined to determine if it is muddy or otherwise contaminated, as evidenced by floating substances, peculiar color, or odor. Water from sources, which include ponds, streams, rivers, etc., should be carefully examined.

Aggregate shall be examined for contamination with foundation material upon which the stockpile is built, during removal of aggregate from the stockpile. Aggregate shall be examined for spillage or overrun into adjoining aggregate bins during loading of plant bins. Admixtures shall be examined to determine if there has been a thorough agitation before being dispensed in each day's batching operation. The admixture shall be examined for liquid separation, differential concentration, and/or fluctuating air content or set retardation.

(g) Failure to Meet Conformance Criteria for Concrete Cylinder Strength Tests

When the concrete cylinder strength test result(s) fail to meet the conformance criteria, the laboratory will retain the compressive test fragments and the District Materials Engineer will promptly initiate an investigation to determine the significance of the indicated unsatisfactory strength test result(s). As soon as an unsatisfactory strength test result(s) is reported, and before an investigation is begun, the District Materials Engineer will notify the Resident Engineer, and Concrete Supplier, along with other Department personnel as necessary, to coordinate the subsequent investigation. The District Materials Engineer will keep the Resident Engineer and the Concrete Supplier informed of the progress of the investigation steps and the timing of each operation.

The first step in the investigation is to determine if the test results were valid. Form TL-107 is to be used in the determination of validity. After the TL-107 is completed, an evaluation of the findings, to determine test(s) validity, is to be conducted by a committee, preferably composed of the District Materials Engineer, Project Engineer, District Engineer for Construction or Maintenance (as applicable), and the District Structure and Bridge Engineer (as appropriate). The investigation is to continue as illustrated in the Strength Evaluation Graphic, based upon the committee's decision of either valid or invalid test results. If the cause(s) for test results being considered potentially invalid, are directly or indirectly controlled by the contractor, the determination of validity of the test results may be postponed until core tests (if required) are performed. Validity will then be based on a comparison of the core test results and the cylinder test results.

(1) Valid Test Results - If the test results are found to be valid, the reported deficiency is to be considered a confirmed failure of conformance with design strength and a price reduction of 1.0 percent per percent below f'c, down to and including 90 percent f'c, will be applied to the contract unit bid price (however the committee may proceed to section 3 below if other deficiencies are noted). When test results indicate a strength less than 90 percent f'c, an investigation shall be performed in accordance with the provisions of section 3 below.

(2) Invalid Test Results - If the test results are found to be invalid as a result of improper testing or handling procedures, the District Materials Engineer shall proceed as outlined in section (3) below:

(Note: If the test results are equal to or greater than 90 percent design strength, the concrete may be accepted at the discretion of the committee.)

(3) Determination of In-Place Concrete Strength - When the results of the initial investigation confirm that the concrete is either unsatisfactory or questionable, the District Materials Engineer shall proceed with further investigation to determine the strength of the in-place concrete. The strength will be determined from the results of compressive testing of core samples taken from the concrete unit(s) in question.

Six cores shall be taken in pairs in accordance with AASHTO T-24 from the concrete unit(s) represented by an unsatisfactory concrete strength test result(s). The location of each pair shall be selected on a random basis. Where applicable, the randomization procedures in VTM-32 part B, Statistical Method, should be used. Cores within a pair shall be taken within 12 inches (300 mm) of each other. One core from each pair shall be tested in compression. The companion core from each pair will be retained for petrographic examination, if necessary. Any core which, upon removal, exhibits obvious defects resulting from the coring operation shall be discarded and another core shall be taken from that designated area.

Cores shall be transported to the Central Materials Laboratory, Elko (or appropriate District Laboratory), for preparation and testing. Determination of concrete adequacy will be in accordance with section 4 below.

(4) Determination of Concrete Adequacy -

a. The concrete will be considered adequate provided:

   i. The average strength of the core tests is at least 0.85 f'c, and

   ii. No single core test is less than 0.75 f'c, and

   iii. For concrete that has also has a permeability specification, the permeability of the concrete is determined to be less than or equal to the maximum allowed in the Road and Bridge Specifications, Section 217, Table II-17(as amended for “Low Permeability Concretes”, or the table below, which ever has the latest date). This testing must be performed on concrete cylinders and tested in accordance with

VTM-112, Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.

October 16, 2002

Class of Concrete	A5 Prestr	A4.5 Other Design	A4 Gen'l	A4 Posts& Rails	A3.5 Gen'l	A3 Gen'l	A3 Paving	B2	C1	T3	Latex hydraulic cement concrete overlay	Silica fume concrete overlay
Design Max. Laboratory Permeability at 28 Days (Coulombs)	1,500	2,500	2,500	2,500	2,500	3,500	3,500	N.A.	N.A.	N.A.	1,500	1,500

When the investigation is conducted due to valid test results and all of the conditions above are met, a price reduction of 1 percent per percent below f'_c will be applied to the contract unit bid price.

b. If any one of the above conditions is not met the District Structure and Bridge Engineer will conduct a structural analysis of the concrete unit(s) in question to determine the load carrying capacity of the respective unit(s) as necessary. At the same time, the District Materials Engineer will proceed to investigate the probable cause(s) for the unsatisfactory conditions using tests such as petrographic analysis and permeability determination. Final disposition will be as determined by the initial VDOT committee established, and the action taken shall be documented on the Materials Certification (Form TL-131) by the District Materials Engineer.

(h) Establishing Quality of Concrete in the Structure

Design considerations dictate that we be reasonably assured of having obtained the minimum compressive strength specified. Unless a definite cause for a cylinder failure has been found, due to its not having been sampled, molded, handled, cured and/or tested properly, the unit of structure in question shall be cored when indicated by the State Materials Engineer. These cores shall be tested at an age of 28 days or older, and the test results shall be considered to represent the quality of the concrete in that unit of structure. Because this concrete represents material that matures under less than ideal circumstances, strengths that reach 85 percent of the design strength, with no individual specimen below 75 percent, will be considered satisfactory for acceptance. Depending on the location of the concrete in question, the State Materials Engineer may recommend a reduction in the bid price, a treatment to the concrete to prolong its serviceability, or both.

Results of impact hammer tests will not be recognized as an official control or investigation tool. It is possible that the results obtained with this instrument may be too radical and depend on constant calibration and uniform individual technique. Therefore, acceptance or rejection of structures will not be based on the results obtained with this instrument.

Sec. 416.02 Responsibility of Concrete Producer

(a) Materials

The quality control and condition of all materials used in concrete, as well as all necessary adjustments required in using the materials, shall be the responsibility of the concrete Producer, in accordance with Sec. 219 of the Road and Bridge Specifications.

(b) Personnel

All sources supplying concrete to the Department shall be required to have present during batching operations certified personnel, as outlined in Sec. 219 of the Road and Bridge Specifications. (See also conditions for waiver of this requirement.)

(c) Equipment

Requirements for approval of concrete plants of particular note, in addition to others outlined in the Road and Bridge Specifications, are as follows:

(1) Suitable equipment shall be available at the plant for determining aggregate moisture, air content, and slump.

(2) The amount of air-entraining admixture shall be added within a limit of accuracy of 3 percent, and shall be dispensed by means of an approved graduated transparent device to the mixing water as the water is being put in the mixer.

(d) Performance of Control Tests by Concrete Producer

All control tests and batch adjustments are to be performed by the Certified Concrete Technician, with the exception that the Certified Concrete Batcher may make aggregate moisture tests and adjust aggregate design weights to batch weights, provided that this authority is so noted on his certificate.

The certified employees of the concrete Producer are expected to perform aggregate moisture tests, air checks, and consistency checks.

(e) Reports

The Producer's Technician shall prepare and distribute Form TL-28A for each load of concrete batched for State work at his plant, as outlined in Sec. 800. He shall also keep other records, as outlined for concrete herein, and as outlined in Sec. 800.

(f) Adding Additional Water or Other Ingredients to Batch at Job Site

Should the Contractor desire greater workability in concrete, he should notify the Producer in order that the proper adjustments can be made at the plant by the Certified Concrete Technician.

When the mixing water is to be added to the batch at some point other than at the plant along with the other ingredients, the operation shall be performed by the Producer's Certified Concrete Technician and/or Batcher, with exceptions noted below. The water shall be measured and discharged in accordance with the Road and Bridge Specifications.

For those load(s) already on the job or in transit to the job which lack sufficient workability, the Contractor may assume the responsibility for the adding of additional water, or he may obtain authorization to do so from the Producer, provided the maximum water content or slump specified is not exceeded.

The Project Inspector shall not direct the adding of water to a batch of concrete, but shall reject any load to which water has been added in excess of the maximum water content or slump specified.

It is intended that the main volume of mixing water be added at the batch plant, under the supervision of a Certified Technician or Batcher and recorded by a Certified Batcher on Form TL-28A. It will be permissible, however, to withhold during initial mixing up to one gallon per cubic yard (5 liters per cubic meter), if required. Upon arrival at the job site, this water withheld at the plant should be added to the mix, just prior to discharge, provided that the maximum mix design water content is not exceeded. This water may be added in more than one increment, until the desired consistency is obtained. This water adjustment will require no certified personnel to be present. However, this adjustment of water will still be the responsibility of the Contractor. If water is to be added to the batch, the truck mounted water tanks shall be full on arrival at the job site.

If it is found to be necessary to withhold more than one gallon of water per cubic yard (5 liters per cubic meter) of concrete at the batch plant, then the mix should be redesigned immediately. If the maximum allowable water-cement ratio and slump are not exceeded, then the full amount of all ingredients specified in the approved mix design should be added, or else the yield will be affected.

In cases where additional water that has been withheld at the batch plant is added at the job site, it will be necessary to provide some additional mixing at the job, in accordance with the Road and Bridge Specifications. It should also be noted that no mixer water is to be used for the washing of any equipment during the period of the batching operation.

With the above noted exception, when any ingredient is to be added in whole or in part at the job site, this is considered a batching operation and the requirements for a Certified Technician or Batcher will be maintained. However, if the only ingredient to be added at the job site is cement, and if it is to be added in whole bag increments, the presence of a Certified Technician or Batcher will not be required.

Mixing will begin immediately after all ingredients are in the drum. The provision for a 30 minute delay after the cement comes into contact with moisture only applies where the mixing water will be added later. When all ingredients are added at one time, mixing should commence immediately.

See also Sec. 405 for details of designing and batching mix.

(g) Use of Recycled Wash Water

The Producer may use a portion of the recycled wash water, obtained from the mixer washout operation, in subsequent concrete mixing operations, in accordance with Sec. 218 of the Road and Bridge Specifications. This is permissible, provided the wash water conforms to the acceptance criteria outlined in ASTM C94, Tables 1 and 2. The pH values for recycled wash water are waived.

The District Materials Engineer should resample wash water periodically to ensure that the recycling process is consistent, that as much aggregate and cement sludge as possible has been removed, and that at no time is wash water being used directly from the ready-mix truck.

SECTION 417 SUMMARY OF MINIMUM ACCEPTANCE SAMPLING REQUIREMENTS

Following is a condensed tabulation showing the minimum requirements for acceptance testing of hydraulic cement concrete. See also Sec. 205 for additional details governing minimum sampling.

MATERIAL AND TEST	ROAD AND BRIDGE SPECIFICATION REFERENCE	RATE OF SAMPLING	LOCATION FOR SAMPLING	REMARKS
1. Base and Pavement -				
(a) Air Content	219.08.	One test per hour, and when making flexural specimens.	At job site.	Any of the 3 approved methods may be used for this test. However, with any test method used, readings indicating concrete to be outside of specifications must be confirmed first with test by Pressure Method before rejection of concrete. Enter results on Form TL-28A and/or in project materials records.
(b) Consistency (Slump Test)	219.09.	Two (2) tests daily, and when making flexural specimens.	At job site.	If test on any batch fails, recheck batch immediately before rejecting. Enter results on Form TL-28A and/or in project materials records.
(c) Depth	321.20.	See VTM-26.	At job site.	Drilled by concrete pavement core drill obtained from centralized District Materials location. results reported on Form TL-106.
(d) Flexural Strength	321.08, 321.09, & 321.19.	One beam cast for each day's concreting operation.	At job site.	Consistency and Air Content Tests to be made from same batch. Enter data in project materials record.
(e) Moisture of Aggregates		Two (2) tests daily, or as required. Tests made by Producer's Certified Concrete Technician.	At ready-mix plant, batch plant, or job site.	Enter test results on Form TL-28A, and/or in project materials records.

MATERIAL AND TEST	ROAD AND BRIDGE SPECIFICATION REFERENCE	RATE OF SAMPLING	LOCATION FOR SAMPLING	REMARKS
2. Structural (Bridges, Box Culverts, and Retaining Walls) -				
(a) Air Content.	219.08.	One test per load of concrete, except for bridge decks, in which case one test per truck-load for first 3 trucks and then one test for every third truckload, thereafter, provided results remain within 1.0% of median of design range. Also, test required when making compressive specimens.	At job site, and prior to placing concrete in forms.	Any of the 3 approved methods may be used for this test, except for bridge decks, in which case only the Pressure or Volumetric Methods may be used. However, for any concrete and with any test method used, readings indicating concrete to be outside of specification must be confirmed first with test by Pressure Method before rejection of concrete. Enter results of tests on Forms TL-13 or TL-13A, TL-26A, TL-28A, and/or in project materials records. bridge decks, in which case one test per truck-load for first 3 trucks and then one test for every third truckload, thereafter, provided results remain within 1.0% of median of design range. Also, test required when making compressive specimens.
(b) Consistency (Slump Test).	219.09.	One test per batch (truck), and when making compressive specimens.	At job site, and prior to placing concrete in forms.	If test on any batch fails, recheck batch immediately before rejecting. Enter results of tests on Forms TL-13 or TL-13A, TL-26A, TL-28A, and/or in project materials records.

MATERIAL AND TEST	ROAD AND BRIDGE SPECIFICATION REFERENCE	RATE OF SAMPLING	LOCATION FOR SAMPLING	REMARKS
(c) Compressive Strength	219.10	One set of 3 cylinders per 100 yd (50 m^3) same batch with minimum of 2 sets of 3 cylinders each per structure per class of concrete. Any one set to be made from same batch. See Remarks.	At job site.	Consistency and Air Content Tests to be made from same batch. On large structures with very large amount of concrete, State Materials Engineer may grant permission, upon written request, to reduce number of cylinders per structure required. Enter field data and test results on Forms TL-13 or TL-13A, TL-26A, and TL-28A.
(d) Moisture of Aggregates		Two (2) tests daily, or as required. Tests made by Producer's Certified Concrete Technician.	At ready-mix plant, batch plant, or job site.	Enter test results on Forms TL-13 or TL-13A, TL-26A, and/or TL-28A.
3. Prestressed -				
(a) Air Content	219.08 & 405.	One test on each batch sampled for compressive strength specimens.	At prestressed casting yard.	Tests to be made by Producer's Certified Concrete Technician, using Pressure Method only. The Producer shall keep records of test data for review by Inspector as required.
(b) Consistency (Slump Test)	219.09 & 405.	One test on each batch sampled for compressive strength specimens.	At pre- stressed casting yard.	Tests to be made by Producer's Certified Concrete Technician. The casting yard. Producer shall keep records of test data for review by Inspector as required.

MATERIAL AND TEST	ROAD AND BRIDGE SPECIFICATION REFERENCE	RATE OF SAMPLING	LOCATION FOR SAMPLING	REMARKS
(c) Compressive Strength.	219.14(b) & 405.	Two (2) sets (clusters), each consisting of four (4) 6 x 12 in (150 x 300 mm) cylinders or six (6) 4 x 8 in. (100 x 200 mm) cylinders, per casting operation. Each set shall represent separate batch sampled, and shall be taken from concrete placed at quarter points of casting bed.	At prestressed casting yard.	Tests to be made by Producer's Certified Concrete Technician. The Producer shall keep records of test data for review by Inspector as required.
(d) Moisture of Aggregates.		Two (2) tests daily, or as required. (See Remarks).	At prestressed casting yard (batching/ mixing facility).	Tests to be made by Producer's Certified Concrete Technician. The Producer shall keep records of test data for review by Inspector as required.

MATERIAL AND TEST	ROAD AND BRIDGE SPECIFICATION REFERENCE	RATE OF SAMPLING	LOCATION FOR SAMPLING	REMARKS
4. Miscellaneous (All Concrete Except Items 1,2, and 3.)-				
(a) Air Content.	219.08.	One test per day, and when making compressive specimens.	At job site, and prior to placing concrete in forms.	Any of 3 approved methods may be used for this test. However, with any test method used, with readings indicating concrete to be outside of specification must be confirmed first with test by Pressure Method before rejection of concrete. Enter results on Forms TL-13, or TL-13A, TL-26A, TL-28A, and or in project materials records. Caution should be exercised against setting routine times for taking tests, to avoid prediction of which load will be tested.
(b) Consistency (Slump Test).	219.09.	One test per day, and when making compressive specimens.	At job site, and prior to placing concrete in forms. Exercise same precautions.	If test on any batch fails, recheck batch immediately before rejecting. Enter results of tests on forms TL-13 or TL-13A, TL-26A, TL-28A, and/or in project materials records.

MATERIAL AND TEST	ROAD AND BRIDGE SPECIFICATION REFERENCE	RATE OF SAMPLING	LOCATION FOR SAMPLING	REMARKS
(c) Compressive Strength...	219.10.	One set of 3 cylinders per 250 yd^3 (200 m^3) with minimum of one set of 3 per project. Any one set to be made from same batch.	At job site.	Consistency and Air Content Tests to be made from same batch. Field data and test results recorded on Forms TL-13 or TL-13A, TL-26A, and TL-28A. For projects containing less than 50 yd^3 (50 m^3) of misc. concrete District Materials Engineer may waive requirement for compressive specimens, provided this is documented in project records. Cylinder tests for same class of concrete for other projects supplied on same day from same plant may also be used to satisfy testing requirements.
(d) Moisture of Aggregates.		Two (2) tests daily, or as required. Tests made by Producer's Certified Concrete Technician.	At ready-mix plant, batch plant, or job site.	Enter test results on Forms TL-13 or TL-13A, TL-26A, and/or TL-28A.

NOTE: See Secs. 206 and 207 for additional details of Independent Assurance Sampling and Special Waiver (reduced sampling) requirements.

Plant Approved____________________

Plant Disapproved____________________

Virginia Department of Transportation
Materials Division

Inspection Report of Hydraulic Cement Concrete Plants

__________________________DISTRICT

Plant Inspected ______________________________ Date ________________________________

Location____________________________________ Project ______________________________

I. Type of Plant
Central Mix_________________Shrink Mix ________________ Transit Mix ________________

II. Aggregates

A. Stockpile Condition

1. Does method of handling materials prevent intermingling of stockpiles? Yes____ No____
2. Foreign Matter? Yes____ No____
3. Properly partitioned or separated? Yes____ No____
4. At least an SSD Condition? Yes____ No____
5. Well drained? Yes____ No____

B. Is there evidence of prior inspection? Yes____ No____

C. What provisions are made for heating aggregates? ______

____

III. Cement

A. Is the storage facility weatherproof? Yes____ No____

B. Is there evidence of prior inspection? Yes____ No____

IV. Admixtures

A. Stored and handled to prevent contamination? Yes____ No____

B. Is AEA stored where it will not freeze? Yes____ No____

C. Is the measuring device clean? Yes____ No____

D. Is the measuring device transparent? Yes____ No____

E. Is the device connected to the water line? Yes____ No____

F. Does it measure accurately? Yes____ No____

V. Water

A. Approved or tested source? Yes____ No____

B. If tested, evidence of test. Report No.________________________

C. What provisions if any are made for heating the water? __________

____

VI. Scales

A. Date of Seal _____________________

B. Do scales return to zero when bins are emptied? Yes____ No____

C. If scales are beam type, are they equipped with a tare beam? Yes____ No____

D. If scales are beam type, is there a tell-tale device? Yes____ No____

E. Are working parts of the scale clean? Yes____ No____

F. What adjustments are needed, if any? ____

VII. Bins and Hoppers

A. Are bins and hoppers in good condition physically? (free of holes, etc.) Yes____ No____

B. Is there a separate hopper for cement? Yes____ No____

C. Is the hopper so arranged that material is discharged freely and completely? Yes____ No____

VIII. Mixers

A. Central Mixers

1. Is condition of the drum satisfactory? Yes____ No____
2. Is the mixer equipped with a timing device? Yes____ No____

B. Truck Mixers

1. Is the vehicle equipped with a revolution counter? Yes____ No____
2 Is the manufacturer's plate attached in good condition and readable? Yes____ No____
3. Is the condition of water dispensing device satisfactory? Yes____ No____
4. Does the plant have a current list of all trucks which have been approved by the District Materials Engineer? Yes____ No____

IX. Testing Equipment

A. Are adequate test weights available? Yes____ No____

B. Is adequate equipment available for checking aggregate moisture? Yes____ No____

C. Is an air meter available? Yes____ No____

D. Is a consistency device available? Yes____ No____

X. Administration

A. Is a certified batcher present? Yes____ No____

B. Are moisture determinations being calculated on both coarse and fine aggregate as directed by the specifications? Yes____ No____

C. Is a certified technician available? Yes____ No____
Certification Number ____

D. Is the technician performing their duties in accordance with specifications? Yes____ No____

E. Is there an approved mix design (TL-27) on hand? Yes____ No____

F. Is the TL-28A Form being filled out correctly? Yes____ No____

G. Was the plant batching VDOT work at the time of the inspection? Yes____ No____

NOTE: All questions which are applicable must be answered. When deviations from standard are noted, action taken should be listed below.

REMARKS: (Note general condition of plant, equipment, mixers, etc.)

____
Signature of Person Conducting Inspection

____
Concrete Technician Signature

Virginia Department of Transportation
Materials Division

Inspection Report on Plastic Concrete Testing Equipment, Procedures, and Records

Date ____________________________

Project __________________________

PART I

EQUIPMENT

A. Pressure Air Meter

1. Is meter clean? Yes____ No____

2. Has meter been calibrated? Yes____ No____
   a. Where is calibration figure recorded?_________________________________

3. Is standardized vessel in meter storage box? Yes____ No____

4. Does the meter have any leaking valves? Yes____ No____

5. Is the tamping rod used with the meter the correct size? Yes____ No____

B. Displacement Air Indicator

1. Is all equipment on hand
   a. Air indicator? Yes____ No____
   b. Spatula? Yes____ No____
   c. Syringe? Yes____ No____
   d. Mixing pan? Yes____ No____
   e. Sufficient alcohol? Yes____ No____

2. Are gauge marks on stem of indicator readible? Yes____ No____

C. Slump Cone

1. Is the mold the correct size 12” x 4” x 8” ± 1/8” tolerance (305 x 102 x 203 mm) (± 3.2 mm tolerance)? Yes____ No____

2. Is the tamping rod the correct size? (5/8” (16 mm) diameter, hemispherical tipped, approximately 24” (600 mm) long) Yes____ No____

3. Is equipment clean and in good working order? Yes____ No____

D. Concrete Cylinder Molds

1. Do molds conform to dimensional requirements of AASHTO M205? 4” ± 0.04” (102 mm ± 1 mm) and 8” ± 0.16” (205 mm ± 4 mm) Yes____ No____

2. Are molds clean and in good condition? Yes____ No____

3. Is the tamping rod the correct size? (3/8” (10 mm) diameter by approximately 12” (300 mm) long) Yes____ No____

E. Sample Container

1. Is a suitable sampling container available to sample fresh concrete? (AASHTO T-23, Section 4.9) Yes____ No____

F. Curing Boxes

1. Are adequate curing boxes available? Yes____ No____

2. Do the curing boxes meet the requirements as outlined in the specifications? Yes____ No____

PART II

TESTING PROCEDURES

A. Pressure Air Meter Test (T-152)

1. Does the inspector know correct procedures for operating meter? Yes____ No____

2. Is this meter always used on the loads from which cylinders are cast? Yes____ No____

3. Is the meter used to confirm rejections due to air content? Yes____ No____

B. Displacement Air Indicator Test (T-199)

1. Does the inspector know correct procedures for operating the instrument? Yes____ No____

2. Is inspector familiar with conversion chart for mortar content correction? Yes____ No____

C. Slump Cone Test (T-119)

1. Is the mold wet prior to beginning of test? Yes____ No____

2. Is the surface on which the test is conducted rigid and non-absorptive? Yes____ No____

3. Does inspector know correct procedures for conducting the test? Yes____ No____

4. Is entire test conducted within the prescribed time of 2 1/2 minutes? Yes____ No____

5. Are rejections confirmed by immediately retesting the concrete in question? Yes____ No____

D. Concrete Cylinder Casting (T-23)

1. Does inspector know correct procedure for molding cylinders? Yes____ No____

2. Does inspector know proper method of curing and caring for cylinders until time for shipment? Yes____ No____

PART III

RECORDS

A. Is the TL-28A being completed correctly? Yes____ No____

1. Revolution count in accordance with specifications? Yes____ No____

2. Concrete temperature in accordance with specifications? Yes____ No____

B. Are number of cylinders being cast in accordance with Section 411.01(d) Materials Division Manual of Instructions? Yes____ No____

C. Does inspector have adequate records of test results of fresh concrete? Yes____ No____

D. Is inspector conducting tests certified? Yes____ No____
Certification Number ________________

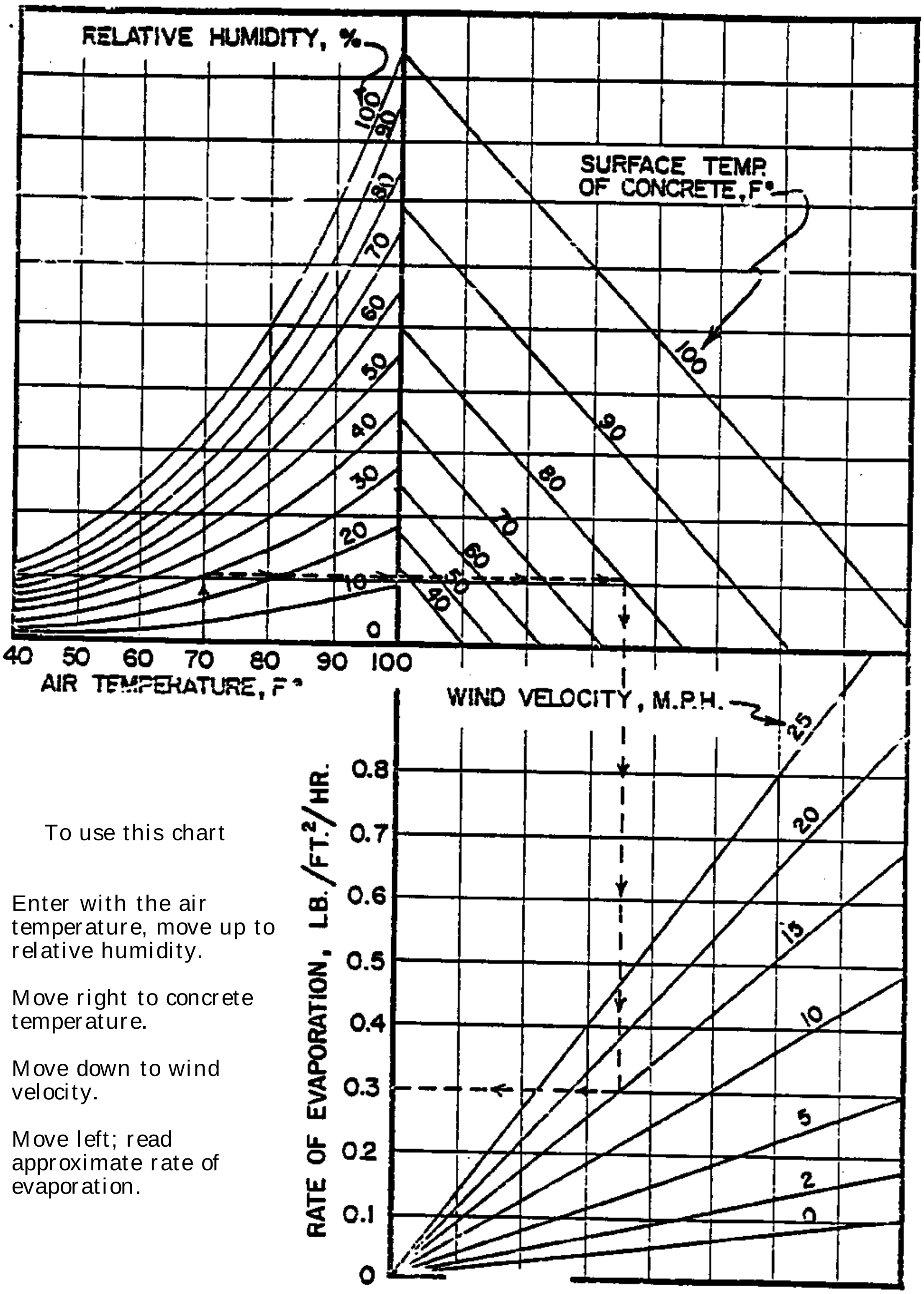
E. Is a certified concrete field technician present during concrete placements? Yes____ No____

NOTE: All questions which are applicable must be answered. When deviations from standard are noted, action taken should be listed below.

REMARKS: (Note general condition of plant, equipment, mixers, etc.)

____
Signature of Inspector

____
Signature of Person Conducting Inspection



To use this chart

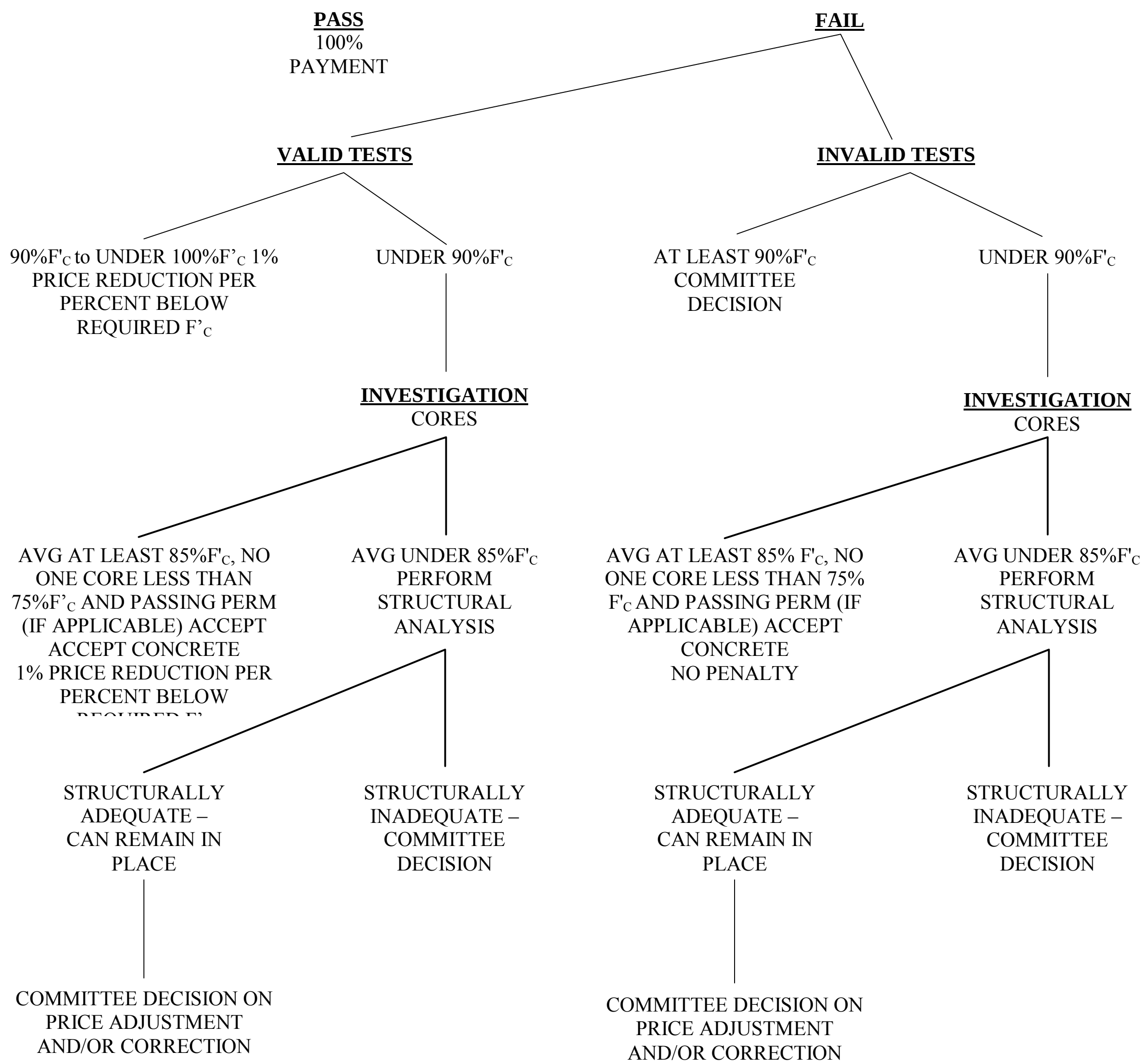
1. Enter with the air temperature, move up to relative humidity.
2. Move right to concrete temperature.
3. Move down to wind velocity.
4. Move left; read approximate rate of evaporation.

Effect of concrete and air temperature, relative humidity, and wind velocity on the evaporation rate of surface moisture from concrete.

<u>Strength Evaluation Graphic</u>

VDOT CONCRETE STRENGTH TEST RESULTS
EVALUATION PROCEDURE

CONCRETE CYLINDERS



February 1999

VIRGINIA DEPARTMENT OF TRANSPORTATION

Concrete Mobile Calibration Data Sheet

PROJECT______________________________ COUNTY____
CONTRACTOR____ DATE______________________
TRUCK NO. ____________________ SERIAL NO. & CAPACITY ________________________________
TRUCK R.P.M. __________________________ CALIBRATED BY ___________________________________

CALCULATING CEMENT METER REGISTER COUNT

NOTE: ACCORDING TO THE MANUFACTURER'S PLATE, THE CEMENT FEEDER METER COUNT TO DISCHARGE A 94 LB. (100 kg) UNIT OF CEMENT HAS BEEN DETERMINED. ENTER THIS COUNT IN THE BOX.

Plate Count [ ]

CEMENT

TOL. +4%
+
- 0%

Container WT:______________

#	LBS (kg)	COUNT	SECS
1			
2			
3			
4			
5			
TL			

Total Counts	Total Weight	Factor (TO 4 Decimals)	Factor	New Cement
÷	=		× 94 =	

Note: RECORD YOUR ANSWER TO ONE DECIMAL AS THE NEW RE-CALIBRATED CEMENT METER COUNT (FOR ONE 94 LB. (100 kg) UNIT OF CEMENT)

New Cement Meter Count [ ]

CEMENT

CALCULATING TIME (IN SECONDS) TO DISCHARGE ONE 94 LB. (100kg) UNIT

Total Seconds	Total Weight	Factor (TO 4 Decimals)	Factor	New Time
÷	=		× 94 =	

Note: Record your answer to one decimal as the new, re-calibrated time in seconds to discharge **One 94 lb. (100 kg) Unit of cement. Enter this figure in the box ⇨ ⇨ ⇨ New Time:** [ ]

SAND GATE Sec. For Calibration________________ Container Wt. _______________ Moisture Content ______________________

TOL. 2%
+
-

DIAL SETTING ⇩	LBS. OF SAND 1	2	3	4	5

STONE GATE Sec. For Calibration________________ Container Wt. _______________ Moisture Content ______________________

TOL. 2%
+
-

DIAL SETTING ⇩	LBS. OF STONE 1	2	3	4	5

LATEX Sec. For Calibration________________ Container Wt. _______________

TOL. 1%
+
-

FLOW SETTING ⇩	LBS. OF LATEX 1	2	3	4	5

WATER Sec. For Calibration________________ Container Wt. _______________

TOL. 1%
+
-

FLOW SETTING	LBS. OF WATER				

1 YD.^{3} Meter Count ____________________ ¼ YD.^{3} Meter Count ________________________________ REV. 5.22/98